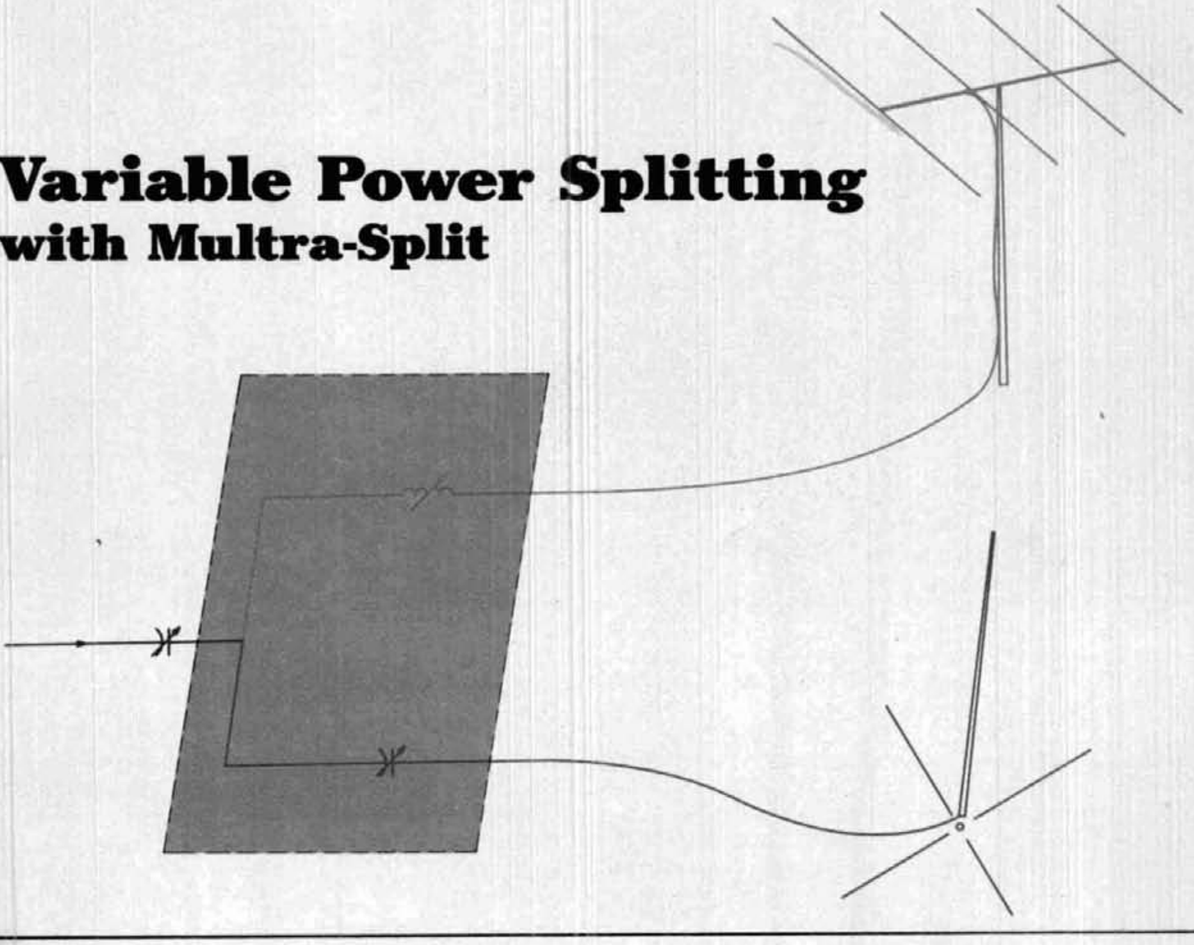
FEBRUARY 1986 / $2.50

ham radio magazine

Variable Power Splitting
with Multra-Split



hr
focus on communications technology

cylindrical feedhorns • two-tone signal generator • the offset drooper: an improved ground plane • improving audio on the ICOM IC-27 • EME link calculator program • quartz crystal resonators • plus W9JUV, W1JR, W6SAI, W6MGI, K4IPV, KØRYW

IC-751

ICOM HF Transceiver

The Standard of Excellence in HF Base Stations

The IC-751 is the most advanced transceiver available today. It's a competition grade ham receiver, a 100KHz to 30MHz continuous tuning general coverage receiver AND a full-featured all mode solid-state ham band transmitter. The IC-751 also covers the new WARC bands, MARS frequencies, and is AMTOR compatible.

Important Standard Features. Compare these important standard features in this "top of the line" base station:

- 100KHz - 30MHz Receiver
- 105dB dynamic range
- QSK — full break-in CW (nominal speed 20WPM)
- FM Mode Standard
- High-grade FL-44A 455KHz SSB filter
- 32 tunable Memories with lithium battery backup
- 100% Duty Cycle Transmitter
- Passband Tuning
- 12V DC operation
- Adjustable AGC
- Adjustable Noise Blanker
- RIT/XIT with separate readout
- IC-HM12 Microphone with Up/Down Scan
- Continuously adjustable transmit power

Options. IC-EX310 speech synthesizer, internal IC-PS35 power supply, external IC-PS15 or IC-PS30 system supply, IC-SM8 two-cable desk mic, IC-SM6 desk mic, RC-10 external controller, and a variety of filters.

FILTER SPECIFICATIONS

Filter	Model	Center Freq. (KHz)	-6dB (KHz) Width
STANDARD FILTERS			
AM Ceramic	CFW 455 IT	455	6.0
SSB (PBT) XTAL	FL-30	9011.5	2.3
FM Filter	9M15A	9011.5	15 (-3dB)
SSB Narrow (Hygrade Crystal)	FL-44A	455	2.4
OPTIONAL FILTERS			
CW Narrow	FL-52A	455	0.500
CW Narrow	FL-53A	455	0.250
SSB Wide	FL-70	9011.5	2.8
CW Narrow	FL-32	9010.6	0.500
CW Narrow	FL-63	9010.6	0.250
AM	FL-33	9010.0	6.0

Operating From 12V, the IC-751 is also available with an optional internal AC power supply, the IC-PS35...for the winning edge in field day competition.

Shown with IC-PS35

The IC-751 provides superior performance for all amateur radio operators...from novice to extra class. See the IC-751 at your local ICOM dealer.

Now with a ONE YEAR Warranty!

ICOM

First in Communications

ICOM America, Inc., 2380-116th Ave NE, Bellevue, WA 98004 / 3331 Towerwood Drive, Suite 307, Dallas, TX 7523-

All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions. 75138

147

TOO GOOD TO BE TRUE?

PAKRATT™ Model PK-64

shown with enhanced
HFM-64 option installed

★ MORSE ★ BAUDOT ★ ASCII ★ AMTOR ★ PACKET ★

FIRST FIVE MODE DATA CONTROLLER

The Pakratt model PK-64 by AEA is the world's first computer interface that offers Morse, Baudot, ASCII, AMTOR *and* Packet all in one box (hardware *and* software included) at a price many competitors charge for Packet alone (from $219.95 Amateur net). Do not let the low price fool you; coming from any other company but AEA it WOULD be too good to be true. The PK-64 works with virtually any voice transceiver. The Pakratt is the easiest of any to hook up and have operating in just a few minutes.

In Packet mode, the PK-64 offers virtually all the features of every other Packet controller on the market, plus many important features left out by others due to cost constraints. For example, we have included a hardware HDLC, true Data Carrier Detect (DCD), multiple connect with up to ten stations simultaneously and full implementation of version 2.0 of the AX.25 protocol.

Because the PK-64 was designed specifically for the Commodore 64 (or C-128 and SX-64) computer, we have been able to do many things not economically feasible with general RS-232 interface controllers. For example, the Pakratt includes true split screen operation with on-screen status indicators and an on-screen tuning indicator.

ENHANCED HFM-64 MODEM OPTION

The standard PK-64 will operate all modes with a phase-lock-loop (PLL) detector roughly equivalent to all popular packet modems in the marketplace (except we have included extra filtering). The enhanced HFM-64 modem option offers true independent dual channel filtering with A.M. detection (like the famous CP-100 Computer Patch™). The enhanced HFM-64 option also offers a hardware LED tuning indicator (like the CP-100) and a front panel variable threshold control for setting maximum sensitivity under various band conditions. We recommend the HFM-64 option for anyone keenly interested in weak-signal heavy-QRM HF operation. For anyone desiring to operate FM RTTY with the standard North American tone pair or CW receive, the HFM-64 is required. The HFM-64 is field installable with no soldering or test equipment required.

WORKS WITH THE POPULAR C-64 COMPUTER

AEA designed the PK-64 around the low-cost C-64 because of the special architecture features making it especially suited to Amateur Radio applications. The C-64 should not be viewed as a mainframe, but rather a very economical accessory to your data communications system. Many owners of expensive computers such as IBM, TANDY, APPLE, KAYPRO, ATARI, etc., are now buying the low cost C-64 and dedicating it to their operating position. They simply cannot find software for their machine that even approaches the power and user friendliness of the PK-64. Plus, think of the convenience of having only one controller and keyboard to go from one mode to another without having to redo cabling!

The PK-64 is so complete that all you need to do is wire up a microphone connector to the end of a cable (provided) and you are ready to go. There is no need to track down special terminal software, cabling or even a power supply. It all comes with the PK-64. So do not be the last on your block to own the most exciting new product in years. See the PK-64 at your favorite dealer or write for our specification sheet now.

Prices And Specifications Subject To Change Without Notice Or Obligation

Advanced Electronic Applications, Inc.
P.O. Box C-2160, Lynnwood, WA 98036-0918
(206) 775-7373 Telex 6972496 AEA INTL UW

AEA Brings you the Breakthrough!

KENWOOD

...pacesetter in Amateur radio

NEW! Computer Interface!

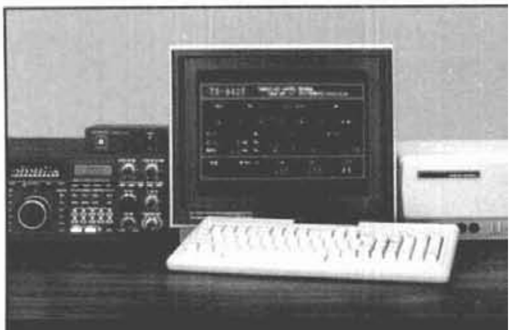
"DX-cellence!"

TS-940S

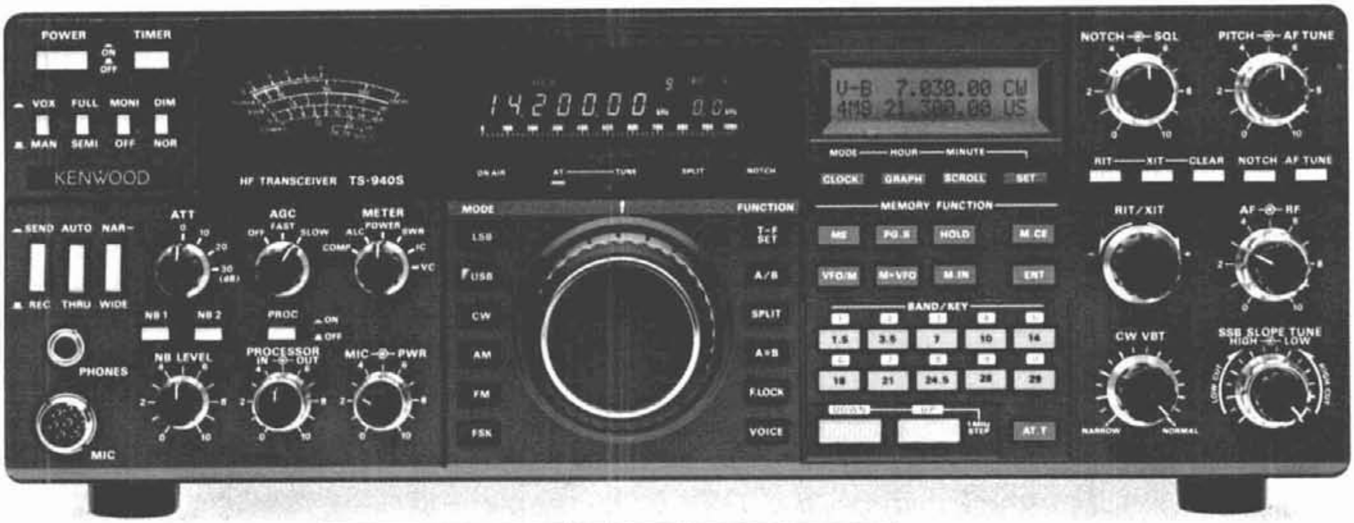
The new TS-940S is a serious radio for the serious operator. Superb interference reduction circuits and high dynamic range receiver combine with superior transmitter design to give you no-nonsense, no compromise performance that gets your signals through! The exclusive multi-function LCD sub display graphically illustrates VBT, SSB slope, and other features.

- **100% duty cycle transmitter.** Super efficient cooling system using special air ducting works with the internal heavy-duty power supply to allow continuous transmission at full power output for periods exceeding one hour.
- **High stability, dual digital VFOs.** An optical encoder and the flywheel VFO knob give the TS-940S a positive tuning "feel."
- **Graphic display of operating features.** Exclusive multi-function LCD sub-display panel shows CW VBT, SSB slope tuning, as well as frequency, time, and AT-940 antenna tuner status.
- **Low distortion transmitter.** Kenwood's unique transmitter design delivers top "quality Kenwood" sound.
- **Keyboard entry frequency selection.** Operating frequencies may be directly entered into the TS-940S without using the VFO knob.
- **QRM-fighting features.** Remove "rotten QRM" with the SSB slope tuning, CW VBT, notch filter, AF tune, and CW pitch controls.
- **Built-in FM, plus SSB, CW, AM, FSK.**
- **Semi or full break-in (QSK) CW.**
- **40 memory channels.** Mode and frequency may be stored in 4 groups of 10 channels each.
- **Programmable scanning.**
- **General coverage receiver.** Tunes from 150 kHz to 30 MHz.
- **1 yr. limited warranty.** Another Kenwood First!

Optional accessories:
• AT-940 full range (160-10m) automatic antenna tuner • SP-940 external speaker with audio filtering • YG-455C-1 (500 Hz), YG-455CN-1 (250 Hz), YK-88C-1 (500 Hz) CW filters; YK-88A-1 (6 kHz) AM filter • VS-1 voice synthesizer • SO-1 temperature compensated crystal oscillator • MC-42S UP/DOWN hand mic. • MC-60A, MC-80, MC-85 deluxe base station mics. • PC-1A phone patch • TL-922A linear amplifier • SM-220 station monitor • BS-8 pan display • SW-200A and SW-2000 SWR and power meters.



Interface IF-232C/IF-10B



25th Anniversary

Complete service manuals are available for all Trio-Kenwood transceivers and most accessories.
Specifications and prices are subject to change without notice or obligation.

More TS-940S information is available from authorized Kenwood dealers.

KENWOOD

TRIO-KENWOOD COMMUNICATIONS
1111 West Walnut Street
Compton, California 90220

ham radio magazine

FEBRUARY 1986

volume 19, number 2

contents

ham radio magazine is published monthly by
Communications Technology, Inc.
Greenville, New Hampshire 03048-0498
Telephone: 603-878-1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Canada and other countries (via surface mail):
one year, $31.00; two years, $55.00; three years, $74.00
Europe, Japan, Africa (via Air Forwarding Service): one year, $37.00
All subscription orders payable in U.S. funds, via international
postal money order or check drawn on U.S. bank

international subscription agents: page 106

Microfilm copies are available from
University Microfilms, International
Ann Arbor, Michigan 48106
Order publication number 3076

Cassette tapes of selected articles from *ham radio*
are available to the blind and physically handicapped
from Recorded Periodicals,
919 Walnut Street, Philadelphia, Pennsylvania 19107

Second-class postage paid
at Greenville, New Hampshire 03048-0498
and at additional mailing offices
ISSN 0148-5989

Send change of address to *ham radio*
Greenville, New Hampshire 03048-0498

REFLECTIONS

a wrong-headed solution for someone else's problem

Anyone who carries on a telephone conversation should have a reasonable expectation that the conversation will be private. That's a concept with which it's difficult to quarrel. After all, like motherhood, apple pie, and the Stars and Stripes, privacy is something that the American citizen takes for granted. For those who'd challenge the right to electronic privacy there are severe penalties against wiretapping and (in the Communications Act of 1934) against the misuse or divulgence of any private communication heard over the airwaves.

However, in the view of the few who are utilizing a relatively small portion of the radio frequency spectrum for a very lucrative business — cellular telephone — that's not good enough. After all the time, money, and technical genius they've invested in developing cellular technology, they've suddenly discovered it's possible for others to eavesdrop on what their customers are saying!

So have they harnessed some of their technical genius to solve this terrible problem? Of course not. They've gone to the place where any and all problems are solved easily and at someone else's expense: Washington, D.C.

And what's the solution that Washington has devised? Very simple. Under the terms of bills presently moving through the U.S. House and Senate, the citizens of the United States will no longer have any fundamental right of access to the radio frequency spectrum. As those bills are written, it will become a crime to listen to any radio frequency unless the government specifically decides the frequency is one to which it will permit the general public to listen.

Bizarre? Of course. Absurd? Certainly, but that's precisely the premise of the "Electronic Communications Privacy Act of 1985." To be sure, the Act will include some exemptions, with the first being, as a matter of course, for "broadcasting." From then on, however, the exemptions will get a bit stickier; the Act's avowed purpose is to "prevent" the casual listener, no matter how innocent his intent, from "intercepting" any radio transmission that is not intended for his ears.

The only exemptions to this blanket closing off of the spectrum to casual listening will be those services specifically excluded at their own request or due to the beneficence of the bill's authors. Since WWV's time signals will probably qualify as "broadcasting," you should be able to continue setting your watch with them, but if your receiver draws a bit off 10.000 MHz and you end up using a nearby unidentified CW signal for code practice, you're going to need a good lawyer if you get caught.

"But Amateur Radio will be one of the exempt services," you may object, "so what's our problem?" That's just it. It isn't *our* problem — it's everybody's problem. Have you ever tuned below the broadcast band to ship-to-shore CW around 500 kHz, to aircraft radio ranges, to the "Lowfers" with their 1-watt rigs on 1750 meters, or to the various odd signals below 100 kHz? Forget it. It's going to be illegal. Have you ever tuned between the international broadcast bands to see what else goes on in the HF spectrum? Forget it. Illegal. Like to hear what's happening at the local airport tower, on marine VHF FM, or the various caboose-to-engine railroad frequencies? Forget it. Illegal!

Of course, some of these frequencies might not be illegal; they might just be included in that hallowed list of exemptions. But do you really want some Congressional staffer in Washington to sit down with a large yellow pad and decide for you each and every frequency he'll let you tune to and which will be forbidden, from DC to light? That's the way the bills are written, and that's the way they're expected to work.

Wrong-headed? This proposal certainly is, because it establishes a position that's precisely 180 degrees contrary to the position firmly established for the American people in the earliest days of radio. That position has, from the very beginning, been that the radio frequency spectrum is a public resource, and with only the very minimum regulation necessary, the right of public access to that spectrum should not be denied.

This right really dates from just after World War I, when the U.S. Navy tried to maintain complete control of the airwaves it had been given when the United States entered the war. When the war began, Amateurs were not only off the air, but also required to take down antennas and dismantle receivers. Within weeks after the war's end, a bill was introduced in Congress to continue Navy control of all radio communications in peacetime, but due in part to Amateur opposition, the bill failed. Nonetheless, it wasn't until April, 1919, that the Navy lifted its ban on Amateur receiving. However, the Navy still wouldn't give up its attempt to retain control of all radio until that September, when a Congressional resolution finally forced it to turn radio regulation back to the Department of Commerce, and Amateurs once again regained the right to transmit.

Though in subsequent years the amount of Amateur spectrum has varied from time to time, the right of Amateur Radio to exist — and for the public to listen to whatever it pleased — was never again seriously challenged . . . at least until now. This isn't because the consequences of unlimited public access to the RF spectrum were not understood; these consequences were addressed in the Communications Act of 1934, which made it unlawful to misuse or divulge information derived from listening to private radio communications. In 1934, at least, the framers of the law were wise enough to realize they could not stop casual radio listening without placing a "Kilocycle Cop" in every household.

So what's really wrong-headed about these bills is their basic philosophy. First of all, they take the position that "We, the elite, have the absolute right to decide what you, the populace, can and cannot do with a radio receiver." With this "right," they take from all of us — SWLs, Lowfers, scanner buffs, Amateurs, and even the guy with a short wave or "public safety" band on his kitchen radio — the right to tune a receiver where it pleases us . . . a right that's existed since before anyone even knew how to tune a receiver.

Furthermore, this proposed law is completely unenforceable. It will succeed only in making criminals out of millions of otherwise honest citizens, while the tiny minority that eavesdrops for illicit purposes will continue to do so with impunity, just as it does today. All this repressive and futile effort, simply to "solve" a problem for a narrow-minded special-interest group with a need to cover up its own self-induced shortcoming — lack of communications security — at the expense of the American people.

This makes me mad — mad enough to tell my Senators exactly how I feel about S-1667 and my Representatives what I think of HR-3378. I hope it makes you that mad, too.

Joseph Schroeder, W9JUV

KENWOOD

...pacesetter in Amateur radio

Handy Handful...

TR-2600A/3600A

Kenwood's TR-2600A and TR-3600A feature DCS (Digital Code Squelch), a new signalling concept developed by Kenwood. DCS allows each station to have its own "private call" code or to respond to a "group call" or "common call" code. There are 100,000 different DCS combinations possible.

- **Simple to operate**
  Functional design is "user friendly." Built-in 16-key autopatch encoder, TX STOP switch, REVerse switch, KEYboard LOCK switch, high efficiency speaker.
- **Large LCD**
  Easy to read in direct sunlight or in the dark with convenient dial light that also illuminates the top panel S-meter.
- **Extended frequency coverage**
  Allows operation on most MARS and CAP frequencies. Receive frequency range is 140-160 MHz. (TR-3600A covers 440-450 MHz.)
- **Programmable scan**
  Channel scan or band scan, search for open or busy channels.
- **SLIDE-LOC battery case**
- **10 Channels**
  10 memories, one for non-standard repeater offsets.
- **2.5 watts high power, 350 mW low**
  TR-3600A has 1.5 watts high or 300 mW low.

The Kenwood TR-2600A and the TR-3600A pack "big rig" features into the palm of your hand. It's really a "handy handful"!

Optional accessories:

- TU-35B built in programmable sub-tone encoder
- VB-2530 2-m 25 W RF power amp.
- ST-2 base stand/charger
- MS-1 mobile stand/charger
- PB-26 Ni-Cd battery
- DC-26 DC-DC converter
- HMC-1 headset with VOX
- SMC-30 speaker microphone
- LH-3 deluxe leather case
- SC-9 soft case with belt hook
- BT-3 AA manganese/alkaline battery case
- EB-3 external C manganese/alkaline battery case
- RA-3 2-m telescoping antenna
- RA-5 2-m/70-cm telescoping antenna
- AX-2 shoulder strap w/ant. base
- CD-10 call sign display
- BH-2A belt hook

More TR-2600A and TR-3600A information is available from authorized Kenwood dealers.

KENWOOD

TRIO-KENWOOD COMMUNICATIONS
1111 West Walnut Street
Compton, California 90220

TR-2600A shown. TR-3600A is available for 70 cm operation.
Complete service manuals are available for all Trio-Kenwood transceivers and most accessories.
Specifications and prices are subject to change without notice or obligation.

presstop de W9JUV

THERE IS A THREAT TO AMATEUR RADIO IN THE "COMMUNICATIONS PRIVACY ACT OF 1985" in spite of an assumption by some observers that "exemption" from its provisions is sufficient protection. It could hurt recruitment, since many future Amateurs become interested in Amateur Radio through casual listening of the type the new bill would prohibit. Furthermore, the total government control of the radio spectrum that it imposes would almost certainly be applied to Amateurs in the future. (For additional in-depth discussion of the proposal's far-reaching negative effects, see this month's editorial.)

TWO CONTRADICTORY BAND PLANS FOR THE NEW 33 CM (902-928 MHz) BAND are now in use, following adoption of its own plan by the Southern California Repeater and Remote Base Association (SCRRBA). The SCRRBA plan, adopted at an 11/16 meeting, totally ignores the ARRL's VUAC-developed plan -- despite the League's plan having been developed over a period of several years and having been well advertised, both before and after its adoption early last year. For example, the SCRRBA plan not only incorporates different sub-bands, but different FM channel spacing and repeater offsets! Neither plan accommodates the Japanese 903-905 MHz personal radios, which could provide an initial source of equipment to encourage startup activity on the band.

Further Delays In Occupying The Band Will Result from this conflict, with makers hesitating to develop 33 cm equipment compatible with two conflicting standards. As a result, competition from other services or for other uses for this choice 26-MHz wide band will continue to surface. For example, one petitioner has proposed the FCC permit the use of low-power video links -- for example, VCRs to TV sets -- throughout the band. ARRL has filed strong comments against the proposal, designated RM-5193 by the Commission, on the grounds that such joint use would result in unacceptable mutual interference.

TWO NEW RUSSIAN SATELLITES ARE SCHEDULED TO BE LAUNCHED in the very near future, possibly in early February. The two birds, designated RS-9 and RS-10, are expected to be placed in low earth orbit with approximately 120-minute periods. RS-9 will have a single Mode A (2 meters up, 10 meters down) transponder, but RS-10 promises to be the most technologically sophisticated Russian Amateur space effort yet.

Mode K (15 Meters Up, 10 Meters Down) and Mode T (a never-before-used 15 meters up, 2 meters down) transponders are believed to be included in RS-10, along with the usual Mode A transponder. A 2-meter beacon on 145.557 MHz and another on 70 cm (still pending license agreements) will also be included.

RS-10 Is Reported To Have Successfully Completed Checkout and be ready for launch, but RS-9 has had some problems. If problems are resolved in time, the two birds should be launched together; otherwise, RS-10 could go up alone.

Another ISKRA Satellite Launch, In Connection With Refueling of the Russian Salyut 7 Spacecraft, is also thought to be imminent. If so, a Mode K transponder will be included. Since this is an even lower altitude event, the satellite lifetime could be as short as a month or so and the orbital period no more than about 90 minutes.

A PETITION FOR A 52-54 MHz "PUBLIC DIGITAL RADIO SERVICE" submitted by Don Stoner, W6TNS, has been designated RM-5241 by the FCC. Stoner's proposal would create a highly automated low-power (1-watt maximum) packet computer-to-computer "hobbyist" radio system, using the top half of 6 meters because of its low usage by Amateurs and unsuitability for other purposes due to the TVI potential. He also suggests there'd be no repetition of the CB chaos of 27 MHz in his service, since he proposes no voice communications -- only data. The FCC released its public notice on RM-5241 on 12/6/85, so the closing date for receipt of Comments was 1/6/86.

THE U.S. AMATEUR POPULATION CREPT TO AN ALL-TIME HIGH of 413,642 individual operators as 1985 drew to a close. The breakdown by license class shows Generals most numerous, with 117,082, followed by Advanced (97,781), Tech (83,387), Novice (77,087), and Extra (38,305). California still has more than twice as many Amateurs as any other state (57,151), with New York (25,897), Florida (24,675), and Texas (24,444) in a close race for second.

Biggest Problem Continues To Be The Novice Class, which is the only license class that's failing to grow. At the end of FCC's fiscal 1983 there were 86,781 Novice licenses in force; a year later that had dropped to 80,461. At presstime the Novice ranks had dwindled by almost another 3400 to 77,087. The continued growth of the higher classes demonstrates the VEC program is working well; the failure is in recruiting new blood.

SPREAD SPECTRUM WILL BE AVAILABLE FOR GENERAL AMATEUR USE ABOVE 420 MHz as of June 1, 1986. Though the new mode may be used for essentially any type of Amateur communication, the rules governing its use are extensive and quite detailed. Potential users should refer to Part 97.71 of the Amateur rules, a new section pertaining only to spread spectrum.

73 MAGAZINE HAS BEEN RETURNED TO ITS FOUNDER, WAYNE GREEN, W2NSD, in a surprise move by CW Communications. CW had acquired 73 as part of the package when they bought Green's computer magazines several years ago, and it was well known in the industry that they've been trying to dispose of it for some time. What is surprising is that Green has returned to the helm, since he'd stated on numerous occasions that he believed Amateur Radio is a dying hobby and he no longer had any serious interest in it.

BEST OF MFJ

MFJ 24 HOUR LCD CLOCKS

MFJ-108 **$19.95**

MFJ-107 **$9.95**

These MFJ 24 hour clocks make your DXing, contesting, logging and SKEDing easier, more precise.

Read both UTC and local time at a glance with the MFJ-108, $19.95, dual clock that displays 24 and 12 hour time simultaneously. Or choose the **MFJ-107, $9.95** single clock for 24 hour UTC time.

Both are mounted in a brushed aluminum frame, feature **huge easy-to-see 5/8 inch LCD numerals** and a sloped face that makes reading across-the-shack easy and pleasant.

You can read hour, minute, second, month and day and operate them in an alternating time-date display mode. You can also **synchronize them to WWV** for split-second timing. Both are **quartz controlled** for excellent accuracy.

They are **battery operated** so you don't have to reset them after a power failure, and battery operation makes them suitable for mobile and portable use. Long life battery included.

MFJ-108 is 4½x1x2 in. MFJ-107 is 2¼x1x2 in.

RTTY/ASCII/AMTOR/CW COMPUTER INTERFACE MFJ-1229 $179.95

Everything you need is included for sending and receiving RTTY/ASCII/CW on a Commodore 64 or VIC-20 and your ham rig. You get MFJ's most advanced computer interface, software on tape and all cables. Just plug in and operate.

The MFJ-1229 is a general purpose computer interface that will never be obsolete. An internal DIP switch, TTL and RS-232 ports lets you adapt the MFJ-1229 to nearly any home computer and even operate AMTOR with appropriate software.

A crosshair "scope" LED tuning array makes accurate tuning fast, easy and precise.

You can transmit both narrow (170 Hz) and wide (850 Hz) shift while the variable shift tuning lets you copy any shift (100-1000 Hz) and any speed (5-100 wpm, 0-300 baud ASCII).

Automatic threshold correction and sharp multi-pole active filters give good copy under severe QRM, weak signal and selective fading.

There's an FM (limiting) mode for easy trouble-free tuning that's best for general use and an AM (non-limiting) mode that gives superior performance under weak signals and heavy QRM.

A handy Normal/Reverse switch eliminates re-tuning while checking for inverted RTTY.

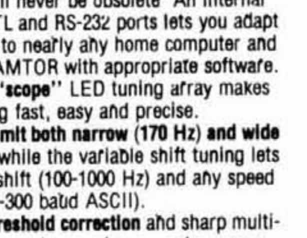
An extra sharp 800 Hz CW filter really separates the signals for excellent copy.

12½ x 12½ x 6 inches. Uses floating 18 VDC or 110 VAC with MFJ-1312, $9.95.

MFJ PORTABLE ANTENNA

MFJ's Portable Antenna lets you operate 40, 30, 20, 18, 15, 12, 10 meters from apartments, motels, camp sites, vacation spots, any electrically clear location where space for full size antenna is a problem.

A telescoping whip (extends 54 in.) is mounted on self-standing 5½ x 6¾ x 2¼ inch Phenolic case. Built-in antenna tuner, field strenght meter. 50 feet coax. Complete multi-band portable antenna system that you can use nearly anywhere. 300 watts PEP.



MFJ-162
$79.95

MFJ ANTENNA BRIDGE MFJ-204B $79.95

Now you can quickly optimize your antenna for peak performance with this portable, totally self-contained antenna bridge that you can take to your antenna site—no other equipment is needed.

You can determine if your antenna is too long or too short, measure its resonant frequency and antenna resistance to 500 ohms. It's the easiest and most convenient way to determine antenna performance available today to anyone. There's nothing else like it and only MFJ has it. Built-in resistance bridge, null meter and tunable oscillator-driver (1.8-30 MHz). Uses 9 V battery. 4 x 2 x 2 inches.

REMOTE ACTIVE ANTENNA

The authoritative "World Radio TV Handbook" rates the MFJ-1024 as "a first-rate easy-to-operate active antenna ... Quiet, with excellent dynamic range and good gain ... Very low noise factor ... Broad frequency coverage ... the MFJ-1024 is an excellent choice in an active antenna"

54 inch remote active antenna mounts outdoor away from electrical noise for maximum signal and minimum noise pickup. Often outperforms long-wire hundreds of feet long. Mount anywhere-atop houses, buildings, balconies, apartments, ships.

Use with any radio to receive strong clear signals from all over the world. 50 KHz to 30 MHz. High dynamic range eliminates intermodulation. Inside control unit has 20 dB attenuator, gain control. Switch 2 receivers and auxiliary or active antenna. "On" LED. 6 x 2 x 5 in. 50 ft. coax. 12 VDC or 110 VAC with MFJ-1312, $9.95.

MFJ-1024
$129.95

200 WATT VERSA TUNER

MFJ-901B **$59.95**

MFJ's smallest 200 watt Versa Tuner matches coax, random wires and balanced lines from 1.8 thru 30 MHz. Works with all solid state and tube rigs. Very popular for use between transceiver and final amplifier. Efficient air-wound inductor gives more watts out. 4:1 balun, 5x2x6 in.

ROLLER INDUCTOR TUNER

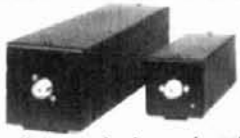
MFJ-989 **$329.95**

Meet the "Versa Tuner V", the compact roller inductor tuner that lets you run up to 3 KW PEP and match everthing from 1.8 to 30 MHz.

Designed to match the new smaller rigs, the MFJ-989 is the best roller inductor tuner produced by MFJ. Our roller inductor tuner features a 3-digit turn counter plus a spinner knob for precise inductance control for maximum SWR reduction. Just take a look at all these other great features! **Built-in 300 watt, 50 ohm dummy load, built-in 4:1 balun and a built-in lighted meter** that reads SWR and forward and reflected power in 2 ranges (200 and 2000 watts). Accuracy ±10% full scale. Meter light requires 12 VDC. 6 position antenna switch. 10¾ x 4½ x 15 inches.

MFJ "DRY" DUMMY LOADS

MFJ-262
$64.95



MFJ-260
$26.95

MFJ's "Dry" dummy loads are air cooled—no messy oil. Just right for tests and fast tune up. Non-inductive 50 ohm resistor in aluminum housing with SO-239. Full load to 30 seconds, de-rating curve to 5 minutes. **MFJ-260 (300 watt)**, SWR 1.1:1 to 30 MHz, 1.5:1, 30-160 MHz, 2½x2½x7 in. **MFJ-262 (1 KW)**, SWR 1.5:1 to 30 MHz, 3x3x13 inches.

MFJ ELECTRONIC KEYER

MFJ-407
$69.95

MFJ-407 Deluxe Electronic Keyer sends iambic, automatic, semi-auto or manual. Use squeeze, single lever or straight key. Plus/minus keying. 8 to 50 WPM. Speed, weight, tone, volume controls. On/Off, Tune, Semi-auto switches. Speaker. RF proof. 7 x 2 x 6 inches. Uses 9 V battery, 6-9 VDC or 110 VAC with AC adapter, MFJ-1305, $9.95.

ORDER ANY PRODUCT FROM MFJ AND TRY IT-NO OBLIGATION. IF NOT SATISFIED, RETURN WITHIN 30 DAYS FOR PROMPT REFUND (less shipping).
• One year **unconditional** guarantee • Made in USA • Add $5.00 each shipping/handling • Call or write for free catalog, over 100 products.

MFJ

MFJ ENTERPRISES, INC.
Box 494, Mississippi State, MS 39762

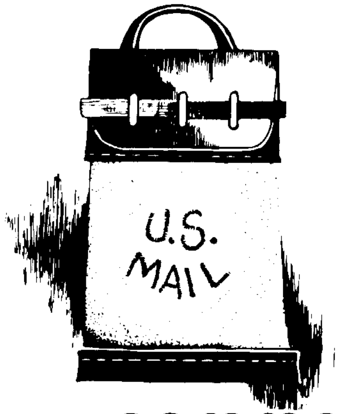
TO ORDER OR FOR YOUR NEAREST DEALER, CALL TOLL-FREE

800-647-1800

Call 601-323-5869 in Miss. and outside continental USA Telex 53-4590 MFJ STKV

VISA MasterCard

✓ 134



comments

odd antennas

Dear HR:

Those of us who have been hams for 30 years but are not radio engineers sometimes wonder about certain unused antenna designs. Perhaps the expertise of the readership of *ham radio* can enlighten us on these peculiar issues.

For instance, every antenna handbook I own describes the advantages in gain of 5/8-wave verticals *and* 1.28 wave dipoles, the 1.28 wave dipole having a 3-dB gain over a half-wave dipole (see the Extended Double Zepp, **fig. 1**). Why aren't more antennas designed using the 1.28-wave element, especially at frequencies above 144 MHz?

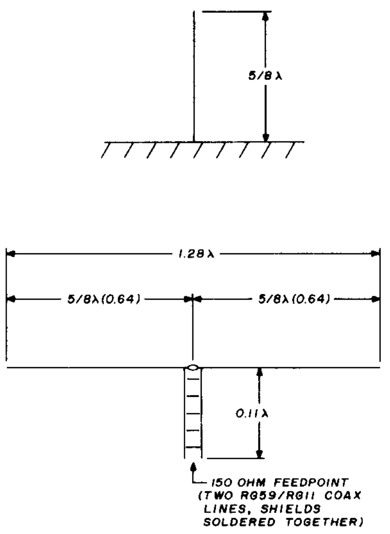


fig. 1. Extended double Zepp.

Every good handbook describes the Windom 14 percent off-center-fed antenna (**fig. 2A**), normally usable at 1/2, 1, and 2-wave frequencies — three bands. Why aren't multi-band dipoles (**fig. 28**) tubular beams (**fig. 2C**) and quads (**fig. 2D**) designed for 3-bands per element 14 percent off-center-feed?

And since the Windom 600-ohm feedpoint occurs at 14 percent off-center (or *64* percent from one end) and the high-gain 5/8-wave vertical is a 62.5 percent feed point, why won't a bent-Windom vertical, fed 64 percent up, with a 36 percent horizontal section, produce a near 5/8-wave superior signal plus a signal on two other bands (**fig. 3**)?

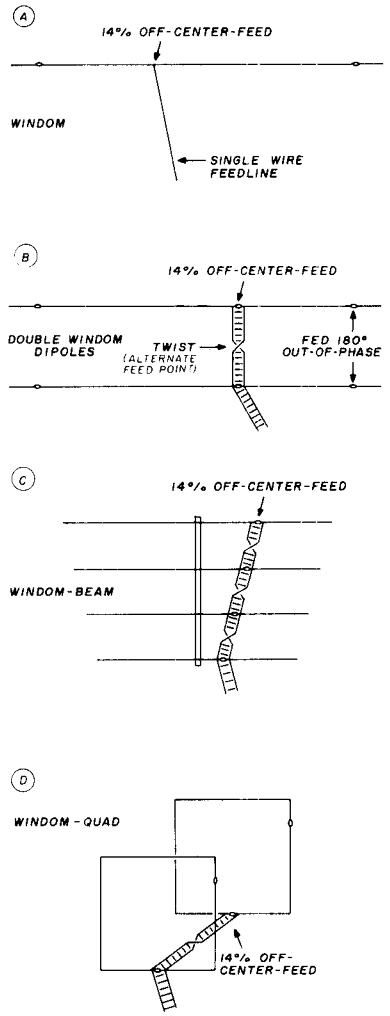


fig. 2. *(A)* Windom dipole; *(B)* Windom-beam; *(C)* double-Windom dipoles; and *(D)* Windom-Quad.

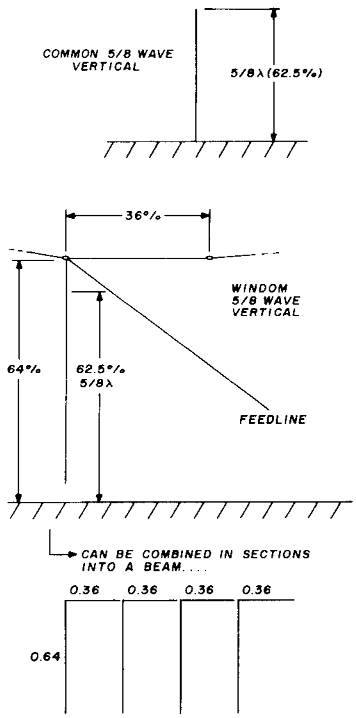


fig. 3. Windom dipole.

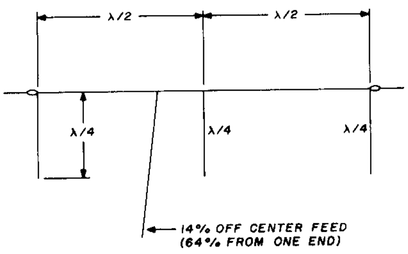


fig. 4. BBBC-Windom.

Since the BBBC (Broadside Bidirectional Bobtail Curtain) (**fig. 4**) antenna is excellent on one band for DX, why can't it be fed at the 600-ohm off-center Windom feedpoint to make it a multiband antenna?

No doubt there are very good reasons why these antennas do not exist, but a good, logical answer would be gratifying to those of us empirical tinkerers who are theory-deficient.

C.N. Francis, WØMBP
Silsbee, Texas

achieve polarization diversity through variable power splitting

Multra-split circuit increases signal strength and extends transmission times

The reception of high frequency (3-30 MHz) signals propagated via the ionosphere is characterized at times by irregular and deep fading (indeed, in such places as the auroral zone, by long periods of excessive absorption resulting in communications blackout). This is related to varying amounts of energy in the vertical and horizontal components of the radio wave. A device at the transmitter that takes account of this condition will enhance communications. Power is divided between two transmitting antennas in such a manner that ratios of from 1:1 to 10:1 can be effected without mismatch. In this manner, vertical and horizontal components of the transmission pattern are compensated to prevent fading at the receiving location utilizing radiation angle diversity. A characteristic of the entire propagation phenomenon during altitude changes of the ionosphere is that the horizontal and vertical components never fade simultaneously. Power splitting takes advantage of this characteristic when other parameters of the system have already been optimized. In this way, communications on a particular band may be extended for up to several hours using this technique.

It is generally accepted that an HF antenna with a low angle of radiation is capable of sustaining usable communications for additional periods as long as two to three hours, during the ionosphere transitional periods.

It is also recognized that during this transitional time some disruption of communications circuits takes place. HF stations normally change their frequencies to re-establish communications. Therefore, any reasonable means that will allow a communicator to extend the transmission period and/or improve the reliability of communications during a transition period, without changing bands, is worth investigating.

During the last 15 years, I have conducted a series of limited experiments on 15 and 20 meters using a transceiver and a pair of antennas. One was a six-element horizontal trap-beam, and the other a vertical antenna. Power from the transmitter was divided between the two antennas by means of a network called *Multra-split*. The Multra-split network allowed the power to be divided anywhere from 1:1 to 10:1 without mismatch at the transmitter.

In practice, the antenna with the highest gain is fed the highest power, and generally the higher gain antenna is horizontally polarized. However, depending upon the band of transmission and time of day, it can be more favorable to feed higher power to the vertical antenna.

sky-wave propagation[1]

At high frequencies, long-distance communication is possible only via sky-wave propagation, whereby radio waves are refracted back to earth from one of the surrounding ionized layers. These layers are the

By John H. Mullaney, W3NGJ, 9049 Shady Grove Court, Gaithersburg, Maryland 20877.

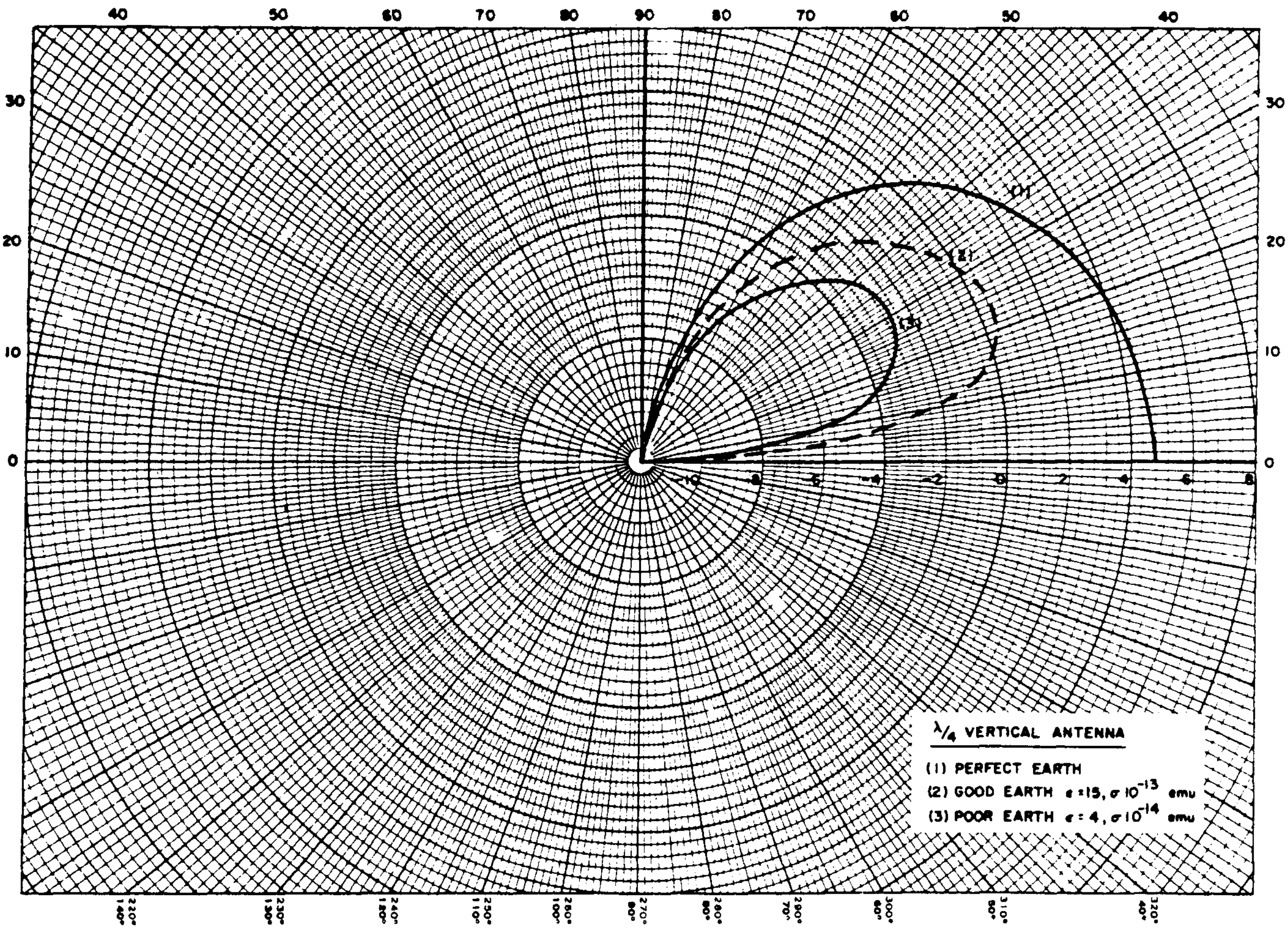


fig. 1. Vertical radiation pattern over earth.

result of ionization of neutral gas in the atmosphere by ultraviolet radiation from the sun.

Because of the variation in the structure of the atmosphere with height and the selective absorption by the various gases of the radiation from the sun, the ionization tends to have several regions of maximum electron density at various heights. These regions are the E-layer, at an average height of 70 miles (113 km), the F1 layer, at about 140 miles (225 km), and the F2 layer, at approximately 250 miles (402 km). Below the E-layer, during the day, is another ionized region at an average height of 35 miles (56 km). This is called the D-region. The D-region accounts for daytime absorption of medium-frequency radio waves. This is the principal reason 80 and 160 are considered night-time bands. These layers, as might be expected (since radiation from the sun is the principal ionizing agent), are present during daylight. At night the D-region is not present, the F1 layer merges with the F2 layer at an average altitude of approximately 175 miles (282 km), and the E-layer essentially disappears.

polarization

Antennas may be classified as linear elements, apertures, arrays, or traveling wave types. For our discussion, and considering that we are interested in Amateur communications in the 2-30 MHz range, we will deal only with linear and array types.

Two field components are present on an antenna: the magnetic and electric fields. Radio waves, like light waves, can have a definite polarization. Radio wave polarization is determined by the orientation of the electric field component, which in turn is determined by the orientation of the elements themselves.

On a linear antenna or an array of elements, the magnetic field component is always at right angles to the radiator, whereas the electric field component is always in the same plane as the radiator. This means that a vertical antenna or radiator will transmit a vertically polarized wave and a horizontal radiator will transmit a horizontally polarized wave.

Most of the common optical effects experienced

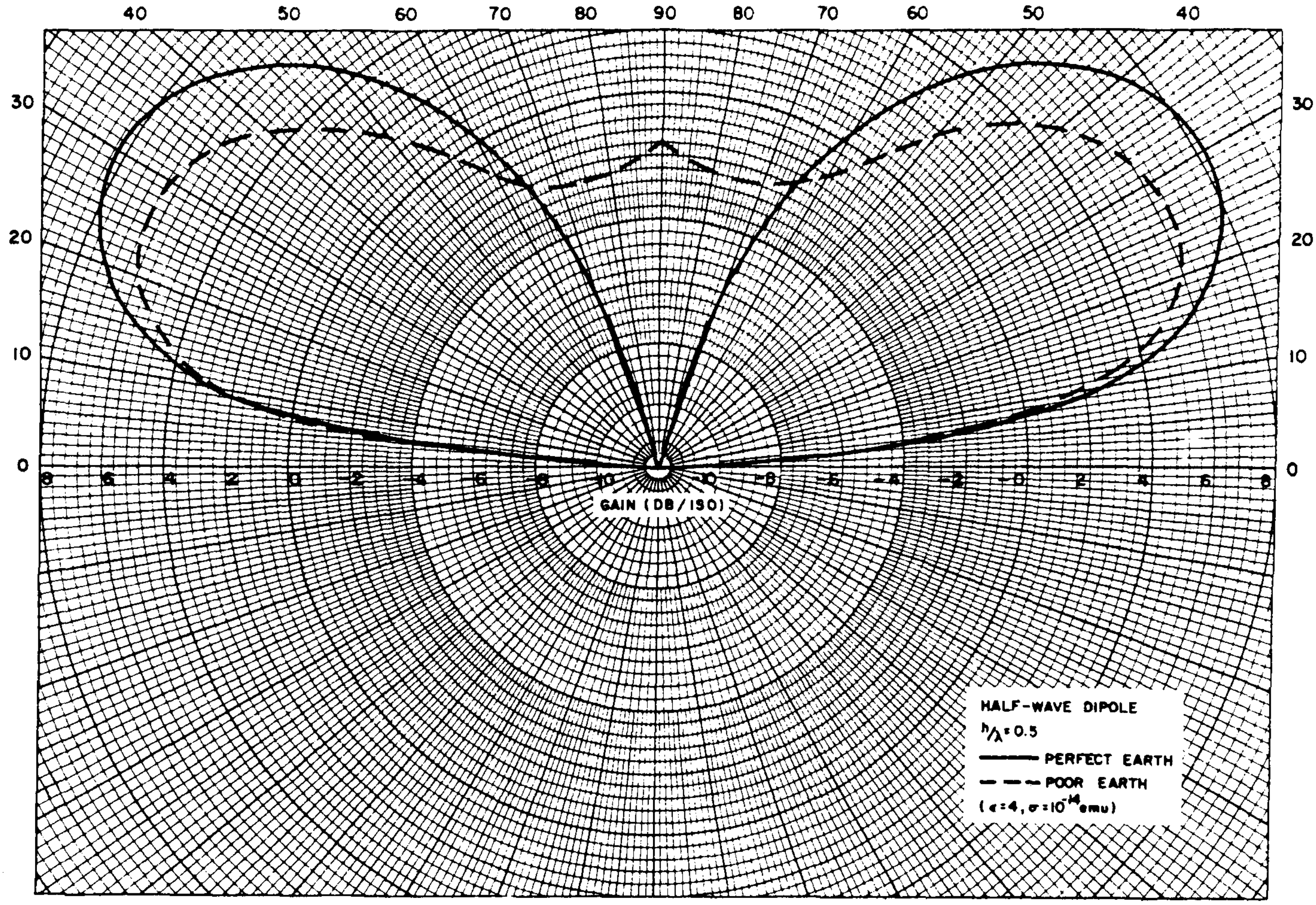


fig. 2. Vertical radiation pattern for horizontal half wave dipole at 180 degrees above earth.

with polarized light also occur between pairs of antennas having different polarizations, when the medium (such as free space) between the antennas does not affect polarization. A linear antenna used for receiving responds most strongly to another antenna with the same polarization, and not at all to one polarized at 90 degrees to the first antenna.

Vertically polarized waves radiated by a vertical antenna over imperfect ground are elliptically polarized because of the presence of a small electric field along the ground in space quadrature and the different time phase from the major electrical component.

For high-frequency ionospheric layer propagation, the received signal is usually elliptically polarized, even when the transmitting antenna produces linear polarization. This condition arises from the effect of the earth's magnetic field on the ionized layers; it splits the incident linearly polarized signal into an ordinary and extraordinary wave. The two waves travel at different velocities and experience different polarization rotations. The resultant received signal is elliptically polarized; consequently, depending on the orientation of the receiving antenna and its height above ground, the received signal may not be usable. The use, therefore, of a vertically and horizontally polarized antenna with a special combining network (such as Multra-split) may provide improved communications not only from a signal strength standpoint, but also over an extended period of time.

The effectiveness of this method of propagation is directly affected by the radiation axis or radiation angle of the antennas used. Whether an antenna is vertically or horizontally excited, its vertical radiation pattern shape is a function of its electrical and physical heights above the ground.

Figures 1 and 2 show the vertical radiation pattern for a horizontal and vertical antenna.

Note that the vertical shape of the elevation pattern is a function of the earth's conductivity. The lower the conductivity, the more pronounced the distortion to the vertical pattern (high angle signals are hardly attenuated). Either antenna can be selected for the high power side, depending upon transmission path conditions.

When we set out to make the best amateur radio equipment in the world, we had some pretty tough standards to live up to ...

... yours

... and ours.

So we designed the **RC-850 Repeater Controller**, the industry's top of the line repeater control system. Now in it's "third wave" of innovation, thanks to its designed for the future architecture and new software releases. The '850 defines the industry standard in repeater control systems.

- Fully remotely programmable with Touch-Tone commands
- Front panel LED display
- Over 300 word customized male and female speech synthesis vocabulary
- Time/day of week Scheduler with 10 set-up states, 30 changeovers and events, over 100 scheduled items for hands off operation and automatic reminders
- Full or half duplex autopatch, autodial (250 numbers), emergency autodial, reverse autopatch, antidialer, toll restrict including telephone exchange tables, supports remote and multiple phone lines
- Informative remotely programmable ID's (17), tail messages (13), bulletin boards (5)
- 16 channel voice response analog metering, automatic storage of min/max values on each channel, values may be read back on command or may be included in any programmable messages
- Supports synthesized remote base transceivers and full duplex links
- Individual user access codes to selectable features
- Mailbox for user-to-user, and system-to-user messages
- Paging – two-tone, 5/6 tone, DTMF, CTCSS, HSC display, user commandable and may be included in programmable messages (i.e. alarms)
- Easy hookup to any repeater

If your repeater budget can't afford the '850, we offer the **RC-85 Repeater Controller**, which we like to call the "second best repeater controller in the world". It's a scaled down, simplified version of our '850, but overall, it offers more capability and higher quality than anyone elses control equipment at any price.

- Remotely programmable with Touch-Tone commands
- Over 175 word customized male speech synthesis vocabulary
- Selectable "Macro sets" for easy control operator selection
- Autopatch, autodial (200) numbers, emergency autodial, reverse patch
- Remotely programmable informative ID's (7), tail messages (3), bulletin board (2)
- Supports synthesized remote base transceiver, control receiver, alarm
- Selectable, informative courtesy tones
- Talking S-meter, Two-tone paging
- Easy hookup to any repeater

For those who like to "roll their own", we can get you off to a rolling start with our **ITC-32 Intelligent Touch-Tone Control Board**. Much more than just a decoder, it's a mini-control system of its own, with the basic repeater and remote base functions built-in. And it can be tailored by you with its Personality Prom.

- 28 remotely controllable latched or pulsed logic outputs
- 4 alarm or remote sensed logic inputs
- Response messages to confirm command entry
- Repeater functions including COR, IDer, timers, courtesy tone, etc.
- Remote base functions including control of synthesized transceiver

Our new **Digital Voice Recorder** lets you remotely record ID's, tail messages, and various other response messages for automatic playback through your repeater. Audio is stored digitally with no-compromise reproduction quality in up to eight megabits of memory. The DVR can support up to three independent repeaters for a low per-channel cost. Its Touch-Tone activated voice mailbox lets your users easily record messages for other users when they aren't around.

- Remotely recordable, variable length audio tracks, accessed from controller messages
- Top quality, no compromise audio reproduction
- Supports up to three repeaters for cost effective installation
- Expandable to roughly 6 minutes of speech in 8 megabits of memory
- Easy interface to RC-850, RC-85 controllers, or to any stand-alone repeater

QST: Attention All Hams

If you own a shack, you should know about ShackMaster™

ShackMaster lets you carry your home station with you in the palm of your hand. It acts as your gateway to the world, linking your handheld transceiver to your high performance HF station. Now, instead of your valuable home equipment being available to you 1% of the time, it's available 99% of the time! Whether around the house, in the yard, or across town, ShackMaster let's you take it with you.

But that's just part of ShackMaster's story. It lets you communicate with the family by handling third party traffic – its electronic mailbox and intercom let you keep in touch. And a simplex patch lets you place important calls directly through your home phone.

- Crossband linking – VHF/UHF to HF
- Telephone access to your home station
- BSR Home Control interface
- Electronic Mailbox
- ShackPatch™ intercom into the shack
- PersonalPatch™ simplex autopatch

All our products are documented with high quality, easy to read manuals. Our goal is to advance the state of the repeater art. But most of all, our products put the FUN back into the FUN MODE!

To order one of these advanced control products, call 408-749-8330. Visa and Mastercard accepted.
Technical manuals are available for purchase and the amount paid is applied as a deposit on the equipment. For specifications and a copy of our ACC Notes newsletter, just write or send in your QSL card to:

acc advanced computer controls, inc.

10816 Northridge Square • Cupertino, CA 95014 (408) 749-8330

More Details? CHECK – OFF Page 110

✓ 188

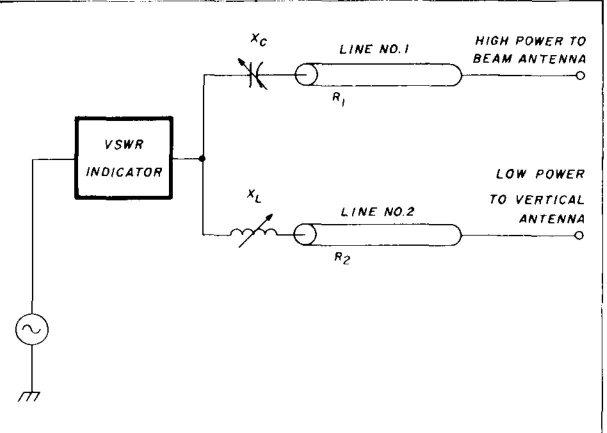


fig. 3. Low power antenna connected to inductive branch.

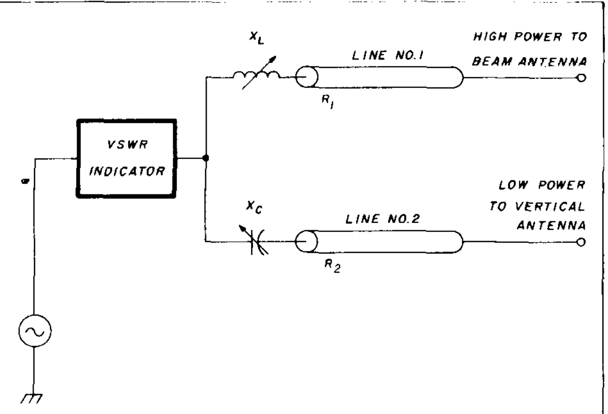


fig. 4. High power antenna connected to inductive branch.

One way to enhance reception and transmission in a varying polarization environment is to use a combiner/power divider network that responds more favorably to the dominant polarization.[2,3] A transmitting type circuit that provides this function (Multra-split) is shown in **fig. 3**. In this case, two antennas — one horizontally polarized, the other vertically polarized — are fed by a network that splits the power as required. This configuration provides more power to the beam antenna. If the polarization that propagates best is vertical, then the **fig. 4** configuration is more appropriate.

circuit operation

The Multra-split circuit is basically a simple power divider. There are two equal loads (50 or 70 ohms), R1, and R2, which represent the transmission line resistance for antennas 1 and 2. Reactances X_C and X_L are of opposite sign and their values are uniquely determined by the power-division ratio and input impedance desired. In this case, the input impedance is selected to match the output of the transmitter (50 or 70 ohms). For our discussion, we will assume the use of 50-ohm transmission lines. The power division is determined by the transmission path conditions. Generally, with a high-gain horizontal beam and a vertical whip, the higher power is fed to the beam and just enough power is fed to the vertical antenna to obtain the diversity effect.

The power division can be expressed in terms of a factor M′, as follows:

$$M' = \frac{P\,(hi)}{P\,(low)} \qquad (1)$$

where
P (hi) = power to fed to Line 1,
P (low) = power fed to Line 2.

The value of reactance for the high-power leg (Line 1)

is:

$$X = \pm \frac{R1}{M'} \qquad (2)$$

where
X = value of positive or negative reactance in ohms,
R1 = Line 1 resistance in ohms,
M′ = power-division factor defined above.

The value of the reactance for the low-power side (Line 2)

is:

$$X = \pm M' \cdot R2 \qquad (3)$$

where
X = value of positive or negative reactance in ohms,
M′ = power-division factor,
R2 = line 2 resistance in ohms (must be equal to Line 1 resistance).

It will be demonstrated later that the input impedance will always be equal to the transmission-line impedances, provided certain design requirements are met. This is the same as saying that, under the required conditions, the feedpoint resistance will always remain equal to the load resistance, regardless of the power division between the two branches.

practical application

Assume a station desired to divide its power on a 90/10 basis; that is, 90 percent in line 1 and 10 percent in line 2. The known parameters are:

f (frequency) = 14.250 MHz.
P (transmitter output) = 500 watts.
R (transmitter output impedance) = 50 ohms.
I (transmitter output current for 500 watts)

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{500}{50}} = 3.16 \text{ amperes.} \quad \textbf{(4)}$$

Current in line 1 for 450 watts:

$$I = \sqrt{\frac{450}{50}} = 3.0 \text{ amperes} \quad \textbf{(5)}$$

Current in line 2 for 50 watts:

$$I = \sqrt{\frac{50}{50}} = 1.0 \text{ ampreres} \quad \textbf{(6)}$$

Power division factor:

$$M' = \sqrt{\frac{P\ (hi)}{P\ (low)}} = \sqrt{\frac{450}{50}} = 3 \quad \textbf{(7)}$$

An inductor is selected arbitrarily for the high power branch. The reactance is:

$$X_L = + \frac{R1}{M'} = \frac{50}{3} = 16.7 \text{ ohms.} \quad \textbf{(8)}$$

Because we selected an inductor for the high power side, a capacitor must be used in the low power branch. Its reactance is:

$$X_C = M' \cdot R1 = 3 \times 50 = 150 \text{ ohms.} \quad \textbf{(9)}$$

and since it's a capacitive reactance = −150 ohms. The magnitude of X_L and X_C have now been determined. The inductance and capacitance can be readily found. The inductance is:

$$L = \frac{0.159 X_L}{f} \quad \textbf{(10)}$$

where

L = inductance in microhenries

X_L = inductive reactance in ohms,

f = frequency in MHz.

solving for L

$$L = \frac{0.159 \cdot 16.7}{14.25} = 0.186\ \mu H \quad \textbf{(11)}$$

The capacitance is determined by:

$$C = \frac{159 \times 10^3}{f \times X_C} \quad \textbf{(12)}$$

where

C = capacitance in picofarads,

X_C = capacitive reactance in ohms,

f = frequency in MHz.

Then:

$$C = \frac{159 \times 10^3}{14.25 \times 150} = 74.39 \text{ pF.} \quad \textbf{(13)}$$

The circuit can now be redrawn as in **fig. 5.**

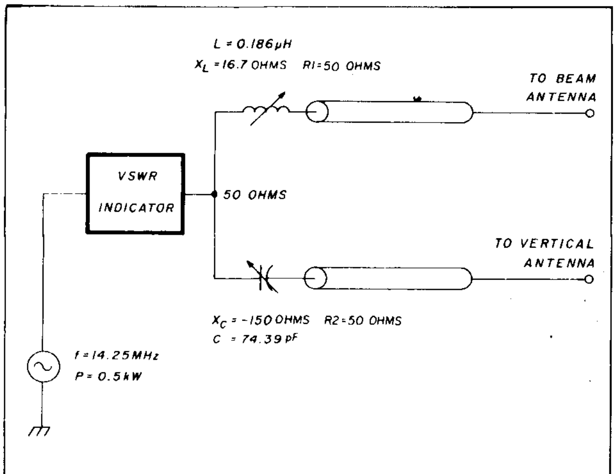


fig. 5. Multra-Split network with matching resistance loads.

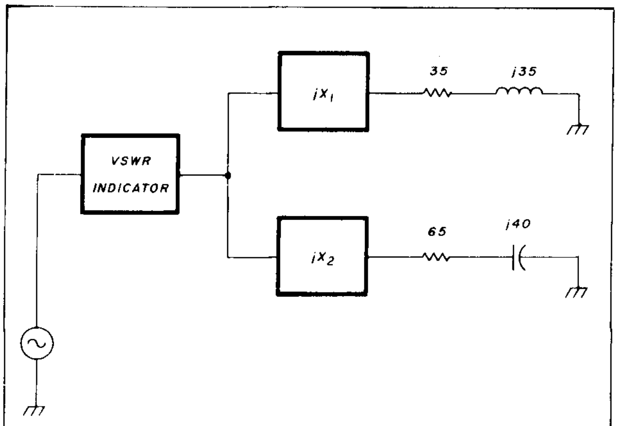


fig. 6. Equivalent circuit for determining components to offset mismatch.

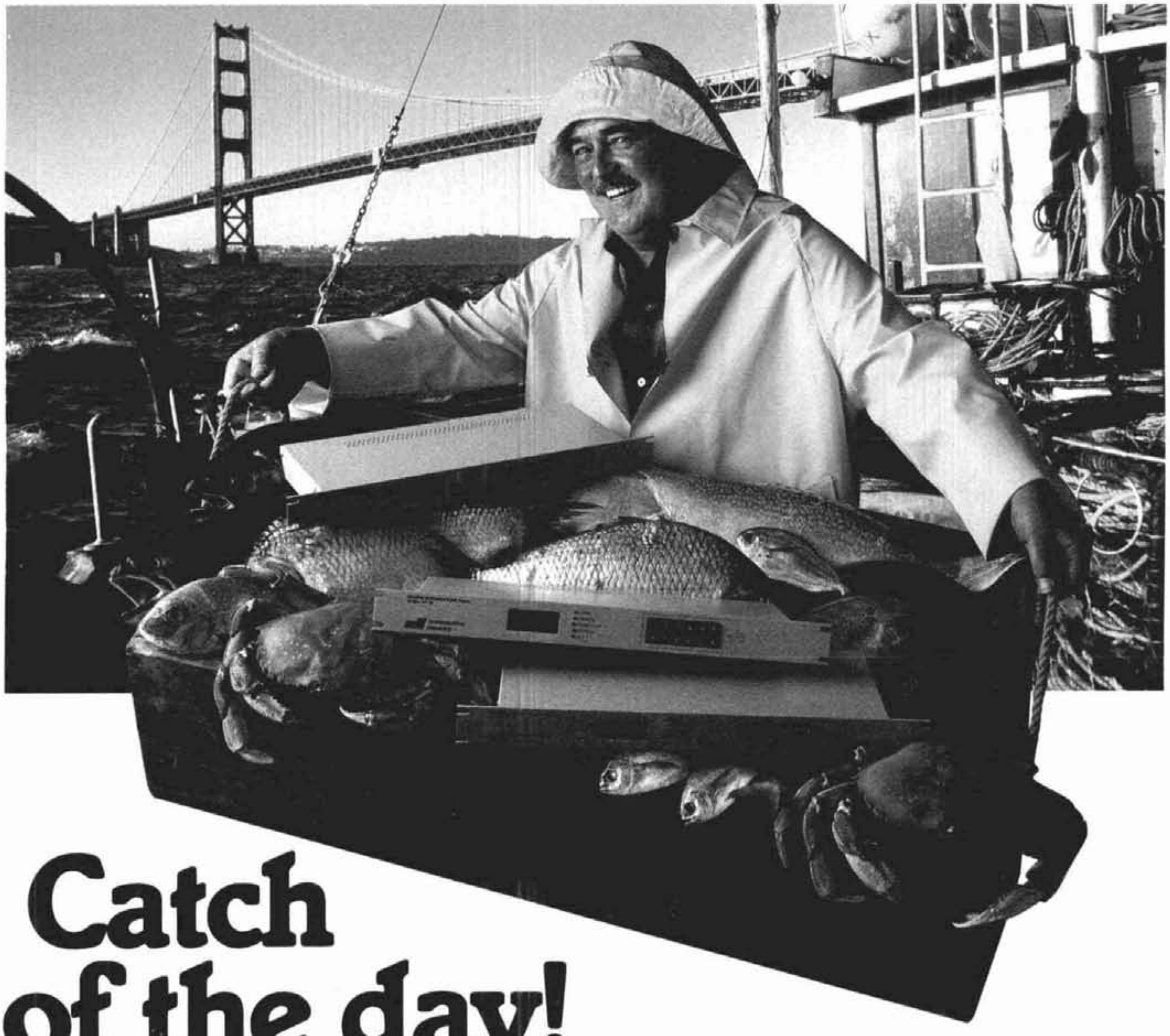
circuit variations

Combinations of X_L and X_C can be selected to accomplish different power splits.

In many cases, it's more practical to use variable capacitors and inductors to obtain the exact power ratio; in others, a fixed capacitor can be made equivalent to a variable unit by using a variable or tapped coil in series with a capacitor.

If you want to operate a transmitter over several bands of frequencies, provisions should be made to switch in different size components. The size and rating of components from a voltage and current standpoint are determined in the usual manner for any network.

It should be noted that the circuit works on the principle that both lines are equal in magnitude and nonreactive. In the event that one or both of the lines are mismatched, it's necessary to adjust the X_C or X_L or



Catch of the day!

Have you been trawling the bounding main for a new product? We have just netted it—the TP-38 microprocessor controlled community repeater panel which provides the complete interface between the repeater receiver and transmitter. Scuttle individual tone cards, all 38 EIA standard

CTCSS tones are included as well as time and hit accumulators, programmable timers, tone translation, and AC power supply at one low price of $595.00. The TP-38 is packed like a can of sardines with features, as a matter of fact the only additional option is a DTMF module for $59.95. This module allows complete offsite remote control of all TP-38 functions, including adding new customers o- deleting poor paying ones, over the repeater receiver channel.

Other features include CMOS circuitry for low power consumption, non-volatile memory to retain programming if power loss occurs, immunity to falsing, programmable security code and much more. The TP-38 is backed by our legendary 1 year warranty and is shipped fresh daily. Why not set passage for the abundant waters of Communications Specialists and cast your nets for a TP-38 or other fine catch.

$595.00 each
$59.95 DTMF module

165

COMMUNICATIONS SPECIALISTS, INC.
426 West Taft Avenue • Orange, CA 92665-4296
Local (714) 998-3021 • FAX (714) 974-3420
Entire U.S.A. 1-800-854-0547

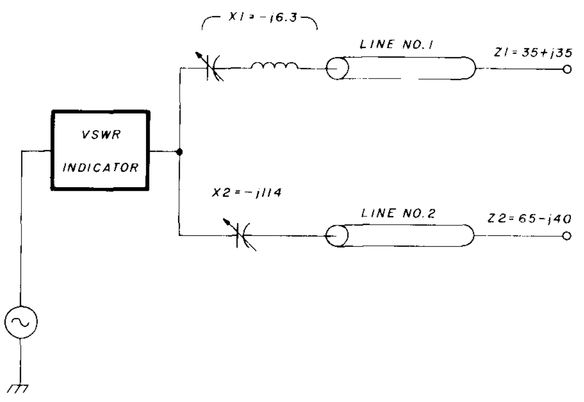


fig. 7. Series network.

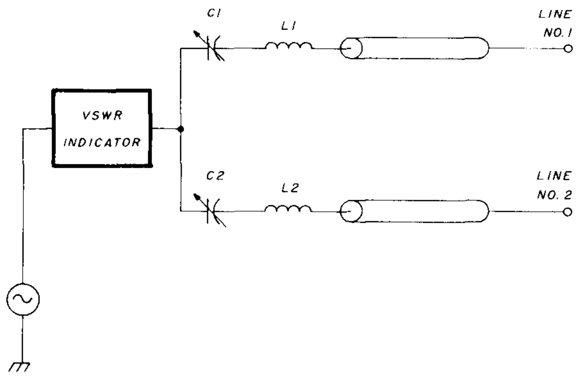


fig. 8. Typical network permitting tuning both arms for plus or minus reactance.

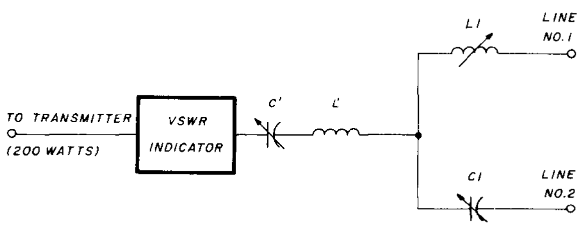


fig. 9. Simplified Multra-Split divider.

both to obtain a 50-ohm input for the transmitter. A VSWR indicator at the transmitter output or network input will indicate a match condition.

Where either or both antennas have a large mismatch, the method for determining the combining components becomes somewhat more complex because we have to deal with four variables; that is, two resistances and two reactances. The problem, however, is not too difficult to solve.

Example Assume:

Transmission line 1 = 35 +j35.

Transmission line 2 = 65 −j40

Power distribution M′ = 3.00 (90 percent/10 percent).

Tramsmitter impedance 50 ohms.

The equivalent circuit can be represented as in **fig. 6**.

The values for jX1 and jX2 are of opposite sign and are determined as follows:

$$X1 = \left[\frac{b^2d - 2ea + \left((b^2d - 2ea)^2 + 4e^2(b^2c - a^2)\right)^{1/2}}{2(b^2c - a^2)}\right]^{1/2} \qquad \textbf{(14)}$$

where

$X1$ = *net reactance for line 1 (the load reactance),*

$$a = R0\text{-}R2 + M'^2\left(\frac{R2}{R1}R_0 - R_1\right)$$

$$b = \frac{2M'\,R0}{R1 + R2}$$

$$c = R2/R1$$

$$d = R2\,R1\left[\frac{R2^2}{M'^2} - R1^2\right]$$

$$e = R1R2 - R0R1 - R0R2 + M'^2\left(\frac{R2}{R1}\right)\left(\frac{R2^2}{M'^2} - R1^2\right)\left(\frac{R0 - R1}{R1 + R2}\right),$$

R_O = *transmitter resistance* = *50 ohms*

Substituting the known parameters, X1 = j 28.7 ohms.

Remember that X1 represents the net reactancce required for branch one; hence, because we already have j 35 in the circuit we must wash out j 6.3 ohms (35-28.7) = 6.3) to obtain the required net reactance. This is best accomplished by a series network adjusted to have a reactance of −j 6.3 ohms in series with line 1.

X2 is determined from (and will be a negative reactance because X1 is positive).

$$X2 = M'\left[\frac{R2}{R1}R1^2 + X1^2 - \frac{R2^2}{M'^2}\right]^{1/2} \qquad \textbf{(15)}$$

Substitute in **Eqn 15** X2 = −j 154 ohms. Inasmuch as the reactance for line 2 is −j 40, we have to add a minus of −j 154 as required by **Eqn 15**. We obtain this value by using a capacitor which is adjusted to −j 114 ohms.

We can now redraw our circuit as in **fig. 7**. In practice we should use a circuit that has series networks in both arms because we can adjust these for either plus or minus reactance, depending upon which side of resonance we are tuned. **Fig. 8** is a typical circuit.

Due to the fact that we are working with mismatched transmission lines, the maximum current and voltages at the input of the lines are determined as follows:

table 1.

	Matched condition Where R1 = R2 = 50 ohms	
P1 percent	**X1 ohms**	**X2 ohms**
10	150.00	16.67
20.00	100.00	25.00
30.00	76.38	32.73
40.00	61.24	40.82
50.00	50.00	50.00
60.00	40.82	61.24
70.00	32.73	76.38
80.00	25.00	100.00
90.00	16.67	150.00

table 2.

	Mismatched condition Where R1 = 35 ohms and R2 = 65 ohms	
P1 percent	**X1, ohms**	**X2 ohms**
10	192.81	12.59
20.00	126.32	18.24
30.00	97.08	28.09
40.00	78.98	38.08
50.00	65.86	48.86
60.00	55.36	61.51
70.00	46.25	77.93
80.00	37.68	102.73
90.00	28.71	153.85

and

$$E_{MAX} = [P \cdot Z_o \times VSWR]^{1/2} \qquad (16)$$

$$I_{MAX} = \left[\frac{P \times VSWR}{Z_o}\right]^{1/2} \qquad (17)$$

where

P = power in watts

VSWR = voltage standing wave ratio,

Z_0 = characteristic impedance of line.

To demonstrate the effect of a mismatch or VSWR vs. a pair of matched lines (**Eqns 1, 14, and 15**) were used to determine the net reactances required for X1 and X2 for the condition where R1 = R2 = 50 ohms,

table 3.

P1 percent	C1 (PF)3	L1(μH)
10.00	58	0.141
20.00	88	0.204
30.00	115	0.313
40.00	141	0.425
50.00	169	0.545
60.00	202	0.686
70.00	241	0.869
80.00	296	1.146
90.00	389	1.717

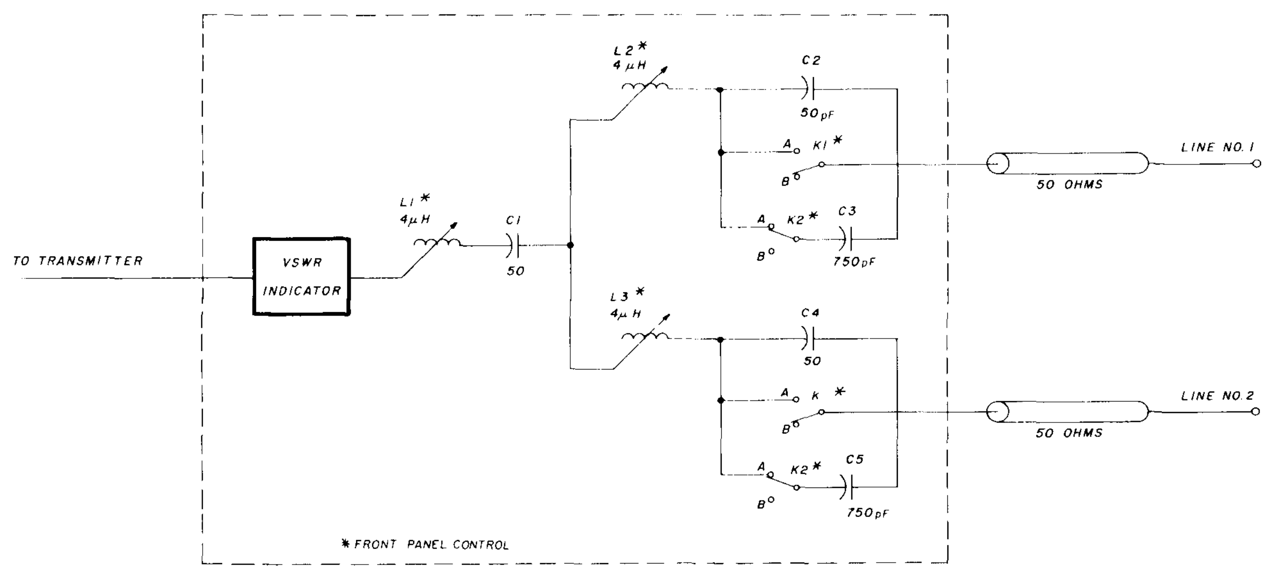


fig. 10. Three band Multra-Split power divider.

and R1 = 35 ohms and R2 = 65 ohms. **Table 1** represents the matched condition, whereas **table 2** is for the mismatched condition.

The differences for identical powers is apparent from a study of the tables. In practical applications, series networks in both legs are used with components large enough to handle any mismatch.

typical multra-split circuits

Figure 9 illustrates a typical stripped-down version of a Multra-Split power divider for one Amateur band.

C′ L′ is a series circuit that can be adjusted either side of resonance to wash out any residual reactance due to mismatch on the transmission lines, while L1 and C1 are the components used to control the percentage of power to each antenna.

Table 3 furnishes typical component values for C1 and for power division from 10 percent to 90 percent where one antenna is a beam and the other a vertical. This divider is for 20 meters with the center frequency being 14.25 MHz. We are using the inductive branch for high power and assume both lines could be mismatched.

C1 would be a variable capacitor of approximately 25-400 picoFarad, while L1 would be a variable inductor of approximately 2.5 μH. The voltage and current ratings of the components would be determined by the transmitter power and VSWR.

The series circuit L′ C′ would consist of a fixed inductor of 4 μH, while a variable capacitor of 25-400 picoFarad would be used for C′.

Figure 10 illustrates another Multra-Split power divider, used by the author, to cover the bands of 10, 15, and 20 meters. It will handle 1 kW of power.

conclusions

The Multra-Split network provides a simple method of dividing power between two loads or antennas of identical or dissimilar polarization radiation angles. It can be used to improve HF communications because it works on the principle of taking advantage of radiation angle diversity. Electrically, the principle is straightforward and it should provide a practical economical method for power splitting.

acknowledgement

Thanks to George Jacobs, W3ASK, for his valuable suggestions and help in preparing this article.

references

1. G. Jacobs and T. Cohen, *Short Wave Propagation Handbook*, C.Q. Publishing, Hicksville, N.Y.

2. John H. Mullaney, P.E., *Improved H.F. Transmission Reception by Use of Power Splitting*, Multronics, Inc., Gaithersburg, Maryland, June, 1969.

3. John H. Mullaney, "A Method for Pre-Sunrise Power Reduction," *Broadcast Engineering*, November, 1967.

ham radio

cylindrical feedhorns revisited

Another look at this popular method

The subject of feedhorn design is obviously of interest to Amateurs and experimenters everywhere; nine years after my first *ham radio* article on this topic, and almost three years after the second, was published, inquiries are still being received.[1,2]

The concept of the open-ended waveguide for use as an antenna or primary feed for a parabolic reflector was covered in the first article; the second article addressed impedance matching to space. Because of limited test pattern facilities, the matter of pattern shape was not thoroughly discussed.

It was only recently that I had an opportunity to make radiation patterns of the cylindrical feedhorn on a professional pattern range with commercial equipment. These tests were made at frequencies between 3.7 and 4.2 GHz because the feedhorns were designed for that frequency range. The results, however, apply equally well on Amateur frequency bands such as 1296, 2304, 5700 and above, wherever parabolic reflectors would normally be used.

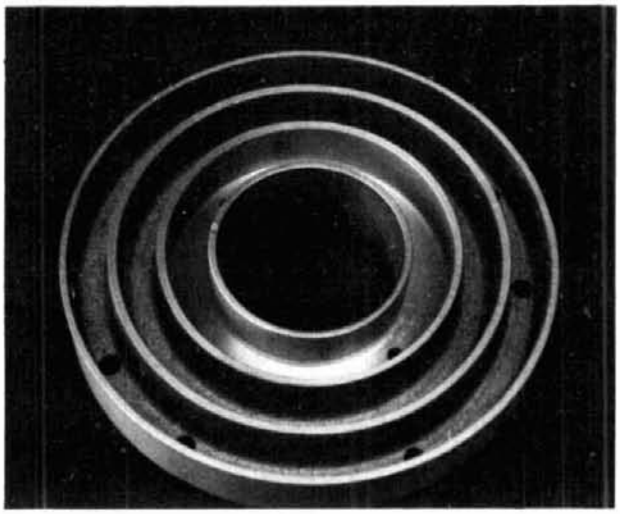


fig. 1. Photograph of typical scalar choke.

A scalar feedhorn is generally defined as one employing an RF "choke" mounted on the outside of the horn near the open end. Commercial feedhorns often employ chokes consisting of four to six concentric rings, either diecast or milled from a block of aluminum. The purpose is to choke off currents that would otherwise flow on the outside surface of the horn, thereby producing unwanted radiation and power loss. A photograph of a typical scalar feedhorn choke is shown in **fig. 1**.

A scalar choke can be fabricated for use at Amateur frequencies by forming copper strips into concentric circles and soldering them onto a brass washer. The height of the strips should be slightly less than a quarter wavelength, spaced approximately 0.2 wavelengths. The latter is not critical, but care should be taken to assure that the circles are concentric.

The choke shown in the second article was a large flat brass washer soldered to a short cylinder that slid over the outside of the horn for positioning. This type of choke is very effective in improving horn efficiency, and is much easier to fabricate than the scalar choke.

Radiation patterns recently made show that the pattern shape using the flat choke is slightly asymmetrical at some frequencies, causing a few degrees of "squint." That is, the axis of the beam tends to be off the horn axis, and this tends to vary with frequency, as shown in **fig. 2**. The shape of the pattern, and in particular its symmetry, is highly important in terms of overall antenna efficiency when a feedhorn

By Norman J. Foot, WA9HUV, 293 East Madison Avenue, Elmhurst, Illinois 60126

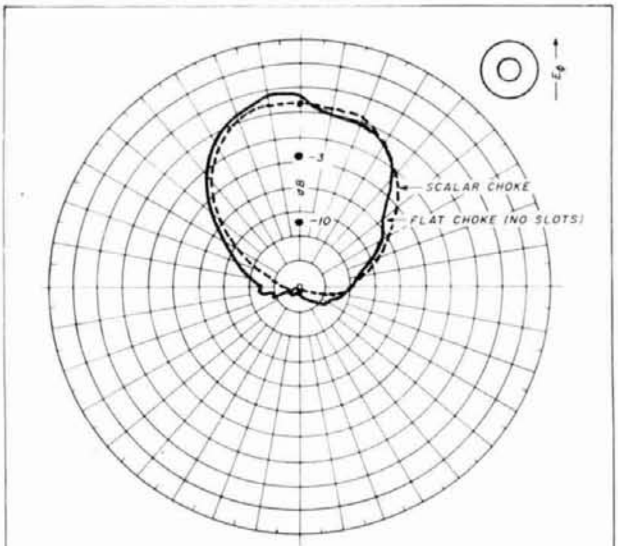


fig. 2. Scalar and flat choke pattern comparison. The flat choke without slots shows a skew off boresight.

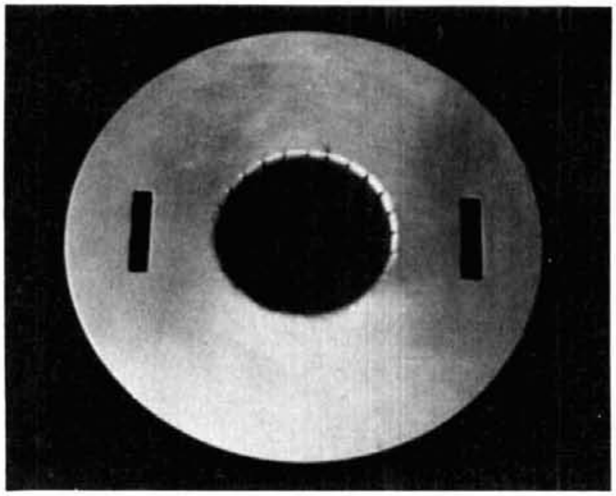


fig. 3. Photograph of slotted choke.

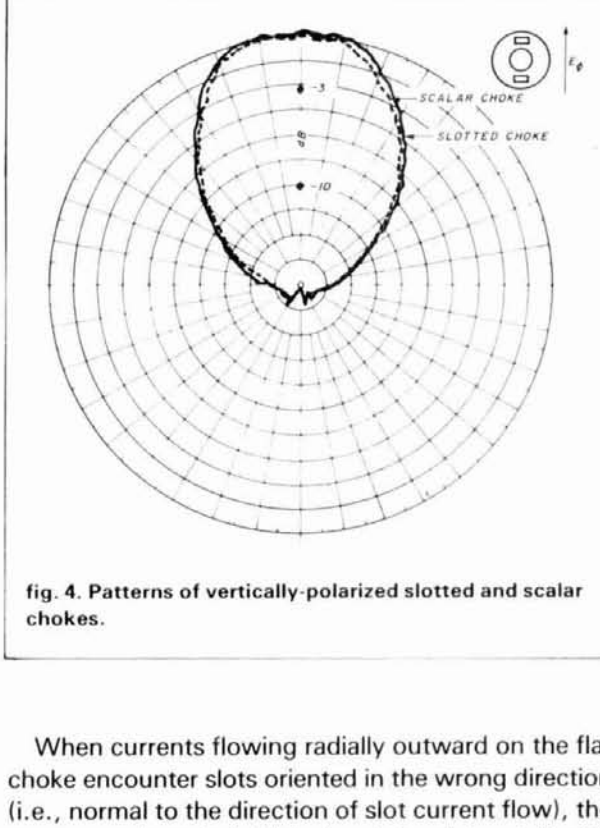


fig. 4. Patterns of vertically-polarized slotted and scalar chokes.

is used together with a parabolic reflector, especially when used over an appreciable frequency band.

overcoming squint

The addition of a single set of resonant slots cut into the choke overcomes the squint problem. The slots act as RF chokes in a manner similar to the concentric rings of the scalar choke. With the addition of the slots, squint is removed and patterns are smooth and axially symmetrical. **Figure 3** is a photograph of a flat choke with slots. Thus, while the addition of a flat choke to the cylindrical feedhorn produces a good match to free space, the slots choke off residual currents that would otherwise flow on the outside of the horn and result in squint. **Figure 4** and **5** compare the patterns of a feedhorn employing a scalar choke with the same horn using a slotted choke. Boresight gains are identical, and 3 and 10-dB beamwidths are for all practical purposes identical. **Figure 4** also shows what can happen when the choke is not used.

slot orientation function of polarization

In operation, the slots are oriented along the direction of polarization. When used with vertical polarization, the slots are located one above the other. Rectangular slots cut in a conducting ground plane are sometimes used as radiating antennas; they are normally excited by connecting a coaxial cable across the small dimension. The resulting RF current tends to flow parallel to the large dimension of the slot. The slot performs like a dipole except that the directions of voltage and current are reversed. The long dimension is approximately equal to a half-wavelength.[3]

When currents flowing radially outward on the flat choke encounter slots oriented in the wrong direction (i.e., normal to the direction of slot current flow), the current tends to be inhibited and the slots act like RF chokes. Choking action is most effective when the slots are resonant at the RF operating frequency. The slots for use at 4 GHz were cut 1.4 inch long and 0.25 inch (3.17 x 0.63 cm) wide. The slot width is not critical as long as it is much smaller than a wavelength.

If the antenna system uses both horizontal and vertical polarization, such as is the case with TVROs two sets of slots should be used to avoid having to rotate the choke 90 degrees to change polarization. A choke of this kind is illustrated in **fig. 6**. Not shown are a

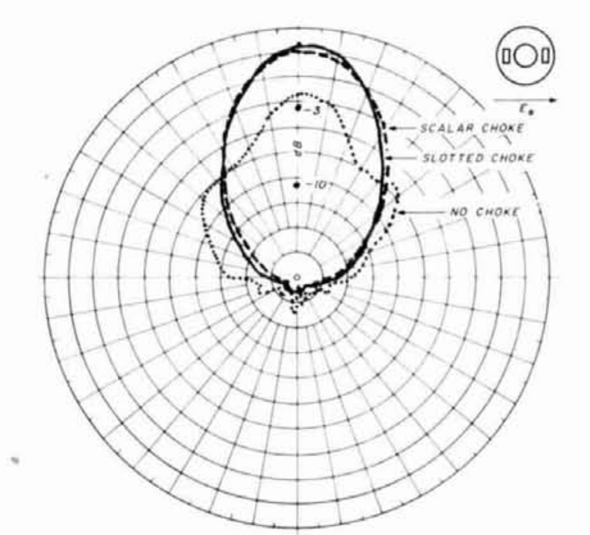


fig. 5. Patterns of horizontally-polarized slotted and scalar chokes.

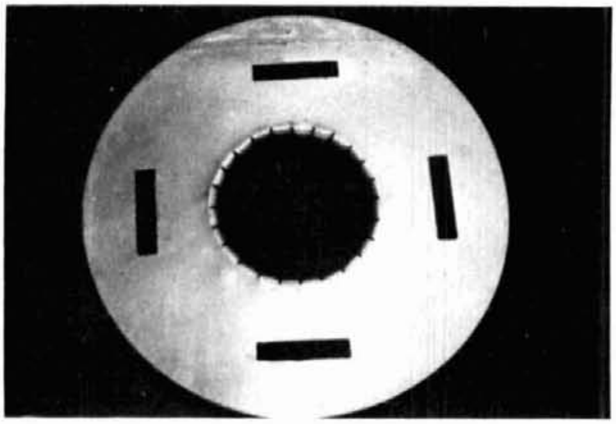


fig. 6. Double slotted choke.

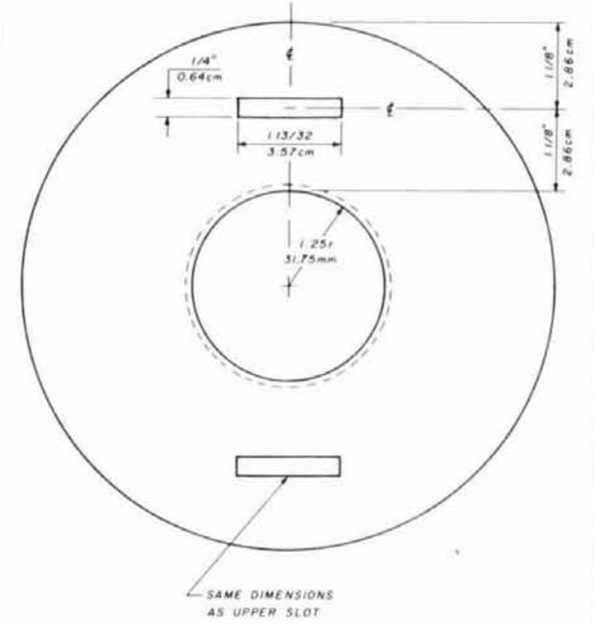


fig. 7. Drawing of slotted choke used in pattern tests.

pair of orthogonally mounted monopoles inside the horn, each of which responds to its respective polarization. Two sets of slots would probably work well with circular or cross-polarization as well, although this has not been confirmed by test.

choke dimensions

The 4 GHz choke shown in **fig. 3** has a 7-inch (17.8 cm) OD and a 2-1/2 inch (6.35 cm) diameter hole at its center which slides over the 2-1/2 inch (6.35 cm) OD horn. The inside diameter of the horn is 2-1/4 inches (5.72 cm) and it is 4 inches (10.16 cm) long. A mechanical drawing of this choke is illustrated in **fig. 7**. In the pattern tests, the optimum location for the slotted choke was found to be in the plane of the open end of the horn. Pushing the choke forward had very little effect on the gain or patterns, but gain falls off somewhat as the choke is moved to a position behind the horn opening.

Choke dimensions can be scaled for operation at other frequencies. The 2304 MHz choke should be 12 inches (30.48 cm) OD and the center hole should be slide-fit with the 3.9 inch (9.91 cm) diameter of the horn. One-pound coffee can make ideal horns for 2304 MHz, since their ID is slightly less than 4 inches (10.16 cm). The choke slots should be 2-1/2 inches (6.35 cm) long and about 3/8 inch (0.95 cm) wide.

At 1296 MHz, the choke diameter becomes relatively large. If scaled from **fig. 7**, it would be 21 inches (53.3 cm). To avoid excessive shadowing, especially when using a relatively small dish, a choke diameter as small as 18 inches (45.72 cm) provides reasonably good performance at 1296 MHz.

A 7/8-inch (2.22 cm) ID brass tube makes an ideal horn for the 10.0-10.5 GHz band. The choke should be 2.7 inches (6.86 cm) OD with 9/16 x 1/8 inch (1.43 x 0.32 cm) slots.

Reader inquiries may be addressed to Footronics Engineering Inc., 293 East Madison Avenue, Elmhurst, Illinois 60126, in care of WA9HUV. Please enclose an SASE.

references

1. Norman J. Foot, WA9HUV, "Cylindrical Feed Horn for Parabolic Reflectors", *ham radio*, May, 1976, page 16.
2. Norman J. Foot, WA9HUV, "Second Generation Cylindrical Feedhorns," *ham radio*, May, 1982, page 31.
3. John D. Kraus, W8JK, *Antennas*, McGraw-Hill, New York, 1950, page 353.

ham radio

New *New*

THE STANDARD OF EXCELLENCE

Definitely Superior!

AZDEN PCS-5000

COMMERCIAL — GRADE

UNPRECEDENTED WIDE FREQUENCY RANGE: Covers 140.000-153.000 MHz in steps that can be set to ***any*** multiple of 5 kHz up to 50 kHz.

CAP/MARS/NAVY MARS, BUILT IN: The wide frequency range facilitates use of CAP and ALL MARS FREQUENCIES including NAVY MARS. ***COMPARE!***

TINY SIZE: Only 2 inches high, 5½ inches wide and 7¼ inches deep!

MICROCOMPUTER CONTROL: Gives you the most advanced operating features available.

UP TO 11 NONSTANDARD SPLITS: ***COMPARE*** this with other units!

20 CHANNELS OF MEMORY IN TWO SEPARATE BANKS: Retains frequency, offset information, PL tone frequency.

DUAL MEMORY SCAN: Scan memory banks separately or together. ***ALL*** memory channels are tunable independently. ***COMPARE!***

MEMORY SCAN LOCKOUT: Allows you to skip over channels you don't want to scan.

TWO RANGES OF PROGRAMMABLE BAND SCANNING: Limits are quickly reset. Scan ranges separately or together with independently selective steps in each range. ***COMPARE!***

BUSY SCAN AND DELAY SCAN: Busy scan stops on an occupied channel. Delay scan provides automatic auto-resume.

DISCRIMINATOR CENTERING (AZDEN EXCLUSIVE PATENT): Always stops on frequency desired when scanning.

PRIORITY MEMORY AND ALERT: Unit constantly monitors one memory channel for signals, alerting you when channel is occupied.

LITHIUM BATTERY BACKUP: Memory information can be stored for up to 5 years even if power is removed.

FREQUENCY REVERSE: Allows you to listen to repeater input frequency.

ILLUMINATED KEYBOARD WITH ACQUISITION TONE: Keys are easily seen in the dark, and actuation is positively verified audibly.

CRISP, BACKLIGHTED LCD DISPLAY: Easily read no matter what the lighting conditions!

DIGITAL S/RF METER: Shows incoming signal strength and relative transmitter power.

MULTI-FUNCTION INDICATOR: Shows a variety of operating parameters on the display.

FULL 16-KEY TOUCHTONE PAD: Keyboard functions as autopatch when transmitting.

MICROPHONE CONTROLS: Up/down frequency control and priority channel recall.

PL TONE GENERATOR BUILT IN: Instantly program any of the standard PL frequencies into the microcomputer. ***COMPARE!***

TRUE FM, NOT PHASE MODULATION: Unsurpassed intelligibility and audio fidelity. ***COMPARE!***

HIGH/LOW POWER: Select 25 watts or 5 watts output — fully adjustable.

SUPERIOR RECEIVER: Sensitivity is better than 0.15 microvolt for 20-db quieting. Commercial-grade design assures optimum dynamic range and noise suppression. ***COMPARE!***

DIRECT FREQUENCY ENTRY: Streamlines channel selection and programming.

OTHER FEATURES: Rugged dynamic microphone, built-in speaker, mobile mounting bracket, remote speaker jack, and all cords, plugs, fuses and bardware are included.

EXCLUSIVE DISTRIBUTOR   DEALER INQUIRIES INVITED   FOR YOUR NEAREST DEALER OR TO ORDER

AMATEUR-WHOLESALE ELECTRONICS   **TOLL FREE...800-327-3102**

8817 S.W. 129th Terrace, Miami, Florida 33176   Telephone (305) 233-3631   Telex: 80-3356

master charge

VISA

MANUFACTURER:

JAPAN PIEZO CO., LTD.

1-12-17 Kamirenjaku, Mitaka, Tokyo, 181 Japan   Telex: 781-2822452

✓ 179

Message Master™

Real-voice message system

For any repeater or base

Now you can communicate vital information even when the station you are calling is not on the air — with Message Master. Message Master is a solid state voice recording system which can record messages just by listening to you speak, store messages in memory, and deliver messages on demand. If you can't be there to deliver your messages let Message Master deliver them for you - any messages in any language and in your own voice!

Message Master connects easily to any radio system for remote access: repeaters, base stations, even transceivers. It can even be connected to an autopatch device to exchange messages between your radio system and the telephone network.

Message Master is a multi-user system with mailbox style personalized message service for a hundred users. With 8 minutes of message storage it can store hundreds of messages simultaneously making it ideal for large, active repeater groups.

Would you like your callsign identifications, tail messages, and bulletin messages sent in real-voice? Message Master can send them too. Record several identification messages and it will even send a different ID each time. Almost like magic, Message Master knows when to send identifications and tail messages so it needs no special control signals from your base or repeater.

Call or write for further information before you make another wasted call.

Commercial users: Ask for a brochure on the Message Master Electronic Dispatcher with group and all call messaging.

- **Create messages just by talking. Message Master's 'real-voice' technique saves YOUR VOICE in digital memory to deliver messages in your own voice, language and dialect.**
- **Mailbox-style operation gives individual message delivery service to 100 system users.**
- **Easily added to any repeater or base station for remote operation with only four connections.**
- **Special features include callsign identifications, tail messages, and bulletin messages.**
- **Digital message storage provides instant playback of stored messages.**
- **Modular memory meets your exact needs from 2 to 8 minutes of total message storage.**

Serving all your repeater needs

— *Mark 4 Repeaters and Repeater Controllers are THE PERFORMANCE LEADERS with real voice, more autodial numbers, more synthesized voice and more features.*

— *Mark 3 Repeaters offer the winning combination of high performance and high value.*

— *LR-1 Repeaters boast superb RF circuitry at an economical price.*

— *MR-4 Receivers with 7 helical resonators are the only receivers to choose in harsh RF environments.*

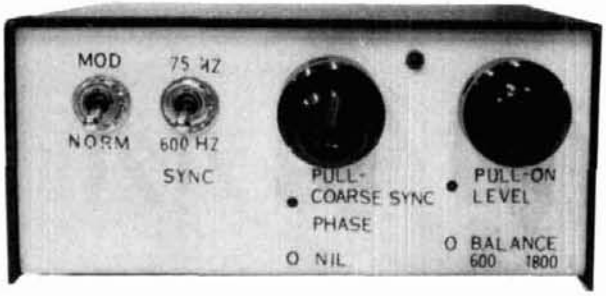
— *PA-100 Amplifiers with rugged TMOS power FETs give you a continuous duty high power signal.*

✓ 143

COMING SOON: A 4-channel receiver voting system which operates on true signal-to-noise ratio to extend your coverage by linking to remote receivers.

KENDECOM INC.
MICRO CONTROL SPECIALTIES

23 Elm Park
Groveland, MA 01834
(617) 372-3442



two-tone signal generator

Check linearity of SSB transmitters with an easy-to-read oscilloscope display

This article describes a two-tone test generator for checking SSB transmitter linearity. In addition to supplying two low-distortion audio tones to the microphone input of a transmitter, it has three additional features. The first permits the generation of a "bow tie" display on an oscilloscope in which linearity shows up as a straight line, which is easily judged, rather than as two interlaced sine waves, which are not so easily judged. The second feature modulates the level of the two tones at a pseudo voice rate, permitting operation at voice average power levels while viewing a two-tone. (Some transmitter power supplies "droop" during single-tone or even two-tone operation, reaching their peak power output only with a voice waveform with its corresponding low average power.) The third feature is crystal control of the frequencies, which permits accurate frequency measurement of a transmitter without the necessity of generating the carrier.

This generator was conceived as a school project almost 20 years ago. Assigned to build a circuit board, we made a two-tone generator that used two twin-tee oscillators, with the high oscillator locked to the third harmonic of the low oscillator with a small capacitor. When the output of the low oscillator, through a phase shift network to compensate for phase shift in the transmitter, was fed to the X input of a scope and the transmitter output was fed to the normal Y input, a "bow tie" pattern resulted, making judging distortion easy. But the tones had significant distortion and the third harmonic lock was unstable. Over the years I tried to improve it by various means, including the use of function generator ICs. This design, which offers maximal features but minimal complexity, is the final product.

operation

For normal operation the output is connected to the microphone input or phone patch input of the transmitter (see **fig.1**). The oscilloscope is usually connected to the RF output via an X10 probe; the RF output is then connected to a 50-ohm dummy load. Turn the transmitter and the test generator on and adjust the balance and level controls for minimum valleys and peak output as shown in **fig. 2A**. The switches should be in the "normal" and "600 Hz" positions. The scope output may be connected to the "external trigger" or "channel B" input to the scope and used to synchronize the display. Varying the phase control will shift the display horizontally.

For a "bow tie" pattern, shift the scope output of the generator to the X input of the scope. Adjust the X channel gain for full horizontal display. With the transmitter on, a pattern similar to **fig. 3** should occur. Rotate the pattern with the phase control to produce a "bow tie" pattern similar to the one shown in **fig. 2B**. (**Figure 2B** was taken with a commercially built Amateur transceiver and appears to be perfect, yet slight variations in linearity are clearly visible in the "bow tie" pattern of **fig. 2B**.) **Figure 4A** shows a pattern produced by a transmitter with severe crossover distortion caused by low screen grid voltage and **fig. 4B** depicts the same with a "bow tie" display. **Figures**

By Bill McLagan, YB9ATA/WA7AQN,
c/o MAF, Box 239, Sentani, Irian Jaya, Indonesia 99000

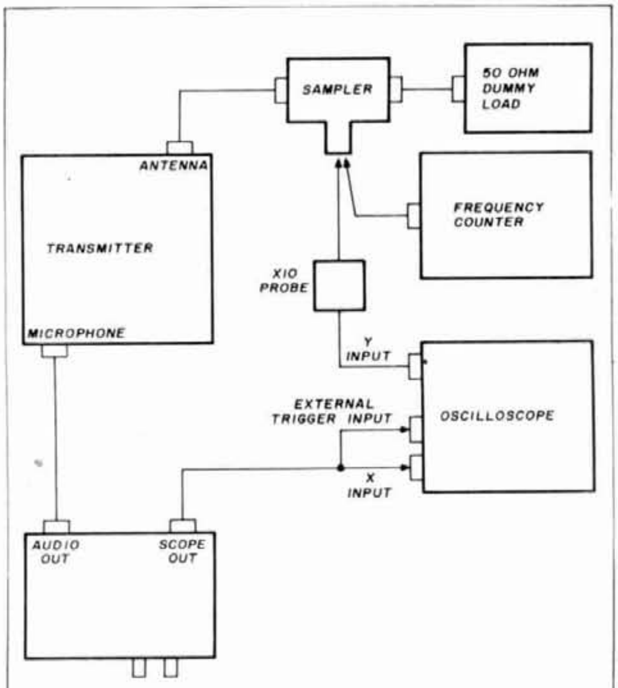


fig. 1. Test connections, two-tone test generator to transmitter.

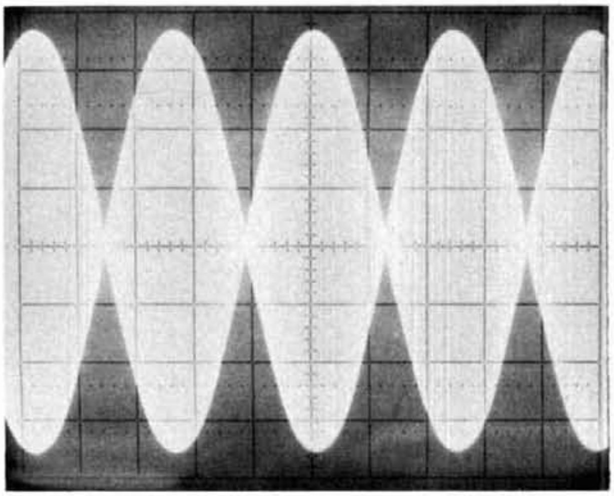


fig. 2A. Output of a commercial transceiver, standard two-tone pattern.

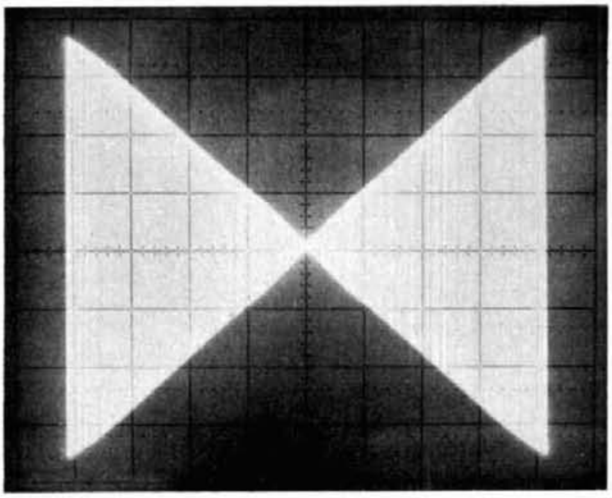


fig. 2B. Output of a commercial transceiver, bow tie pattern.

table 1. Measured power output of a transceiver under test.

Single tone	120 watts
Two-tone	60 watts
Two-tone, pseudo voice	15 watts
Voice ("e" as in "hello")	15 watts
Voice, as above, 20 dB compression	50 watts

5A, 5B, 6A, and 6B show two different kinds of distortion and the resulting patterns.

Figure 7 shows a display using the "modulated" feature to reduce the average power to that encountered during modulation. The synch switch is changed to 75 Hz to synchronize the display. Relative power levels for each mode as measured on a commercially built Amateur transceiver are shown in **table 1.**

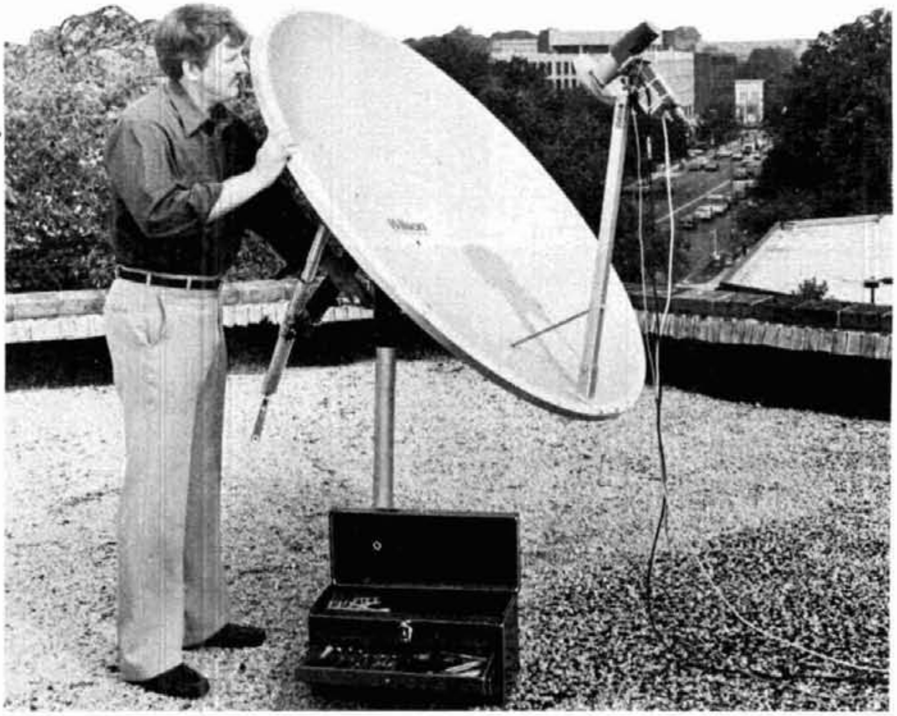
For precise frequency measurement, a single tone is fed into the transmitter. The audio frequency is added to (for LSB) or subtracted from (for USB) the counter reading to arrive at the correct carrier frequency.

theory, digital section

U1, a CD4060, contains an oscillator and a 14-stage binary divider. Y1 can be either a 3.579545 TV crystal (producing output frequencies of 582 and 1746 Hz) or a 3.6864 crystal (producing output frequencies of 600 and 1800 Hz). The tenth binary stage puts out a 3600 Hz square wave, which is fed to U3, a CD4017 decimal counter set up to reset on the third count, resulting in a 1200-Hz asymmetrical square wave.

Both the 3600 Hz signal and the 1200 Hz signal are divided by two by U2 to produce 1800-Hz and 600-Hz symmetrical square waves. The 1800 Hz signal is locked to either the leading or trailing edge of the 600 Hz wave via differentiator C17 and R4, which triggers the reset input of the 1800 Hz divide-by-two section. S4 permits triggering from either the Q or $\overline{Q}$ output of the 600-Hz divide-by-two. This insures that the generator will always start up with the same phase relationship and permits changing the phase 180 degrees to compensate for the less-than-360 degree phase shift available from the "fine" phase control. U7 further divides down the signal to provide 75 Hz

NEW! Satellite Communications Training from NRI!



Move into commercial satellite communications and home satellite TV with NRI's latest training breakthrough

Explore Every Aspect of Satellite Transmission and Reception As You Assemble, Install, and Train With the Complete TVRO System Included in Your Course

With today's satellite technology a call to Paris is as clear and as easy to make as a call next door . . . executives use video conferencing to "meet" without leaving their offices . . . simultaneously, a billion people witness a single event (a soccer game, an inauguration, a benefit rock concert) . . . and scientists explore the mysteries of outer space without leaving their labs.

These amazing applications of satellite technology have opened up exciting new opportunities for the technician trained to install, maintain, troubleshoot, and repair satellite communications equipment.

Home Satellite TV is Just at the Start of Its Explosive Future

In suburban backyards and alongside country farmhouses, home satellite TV systems are springing up all across the country.

Already there are over a million TVRO (Television Receive-Only) systems in place in the U.S. alone, and experts predict that by 1990, a remarkable 60% of U.S. homes will have a satellite dish.

New Jobs, New Careers for the Trained Technician

As an NRI-trained technician, you can concentrate on consumer-oriented TVRO equipment or use your NRI training to build a career servicing the larger commercial or military equipment used to transmit and receive voice, data, and video signals.

NRI Brings Satellite Technology Down to Earth

NRI trains you thoroughly in basic electronics, communications, and television principles. Using the remarkable NRI Discovery Lab® and your digital multimeter, you perform critical experiments, tests, and measurements. Then, using your NRI Antenna Applications and Design Lab, you assemble and test various types of antennas and matching sections.

You then concentrate on both commercial and consumer satellite earth station equipment, putting theory to practice as you assemble and install the complete satellite antenna system included in your course.

Your Home Satellite TV System Brings Theory to Life!

Your Wilson TVRO system comes complete with 5′ parabolic dish antenna system, low-noise amplifier (LNA), down converter, receiver, low-loss coaxial cable, and even a permanent polar mount.

By training with an actual TVRO system, you'll come to understand first-hand the function and operation of a satellite earth station. And once completed, your TVRO system will provide the best television entertainment available—direct from the satellite to your home.

Train the Uniquely Successful NRI Way

It's hands-on training, at home . . . designed around the latest state-of-the-art equipment. You discover by doing . . . and you do it at your own comfortable pace.

Built into your NRI training is the enormous experience of our development specialists and instructors, whose training skills and personal guidance are available to you on a one-to-one basis.

Make Your Move Into the Future Today! Send for Your FREE NRI Catalog

Only NRI can train you at home for an exciting and rewarding career as a satellite communications technician. And now is the time to act. Mail the coupon to us today. You will receive your 100-page catalog free. It details our training methods and materials and our more than 70 years of successful innovation in hands-on career training.

All Equipment Included With Your Training.

NRI SCHOOLS
McGraw-Hill Continuing Education Center
3939 Wisconsin Avenue, Washington, DC 20016
We'll give you tomorrow.

For Career courses approved under GI bill, ☐ check for details.

☑ CHECK ONE FREE CATALOG ONLY

- ☐ **Satellite Communications**
- ☐ Computer Electronics with Microcomputers
- ☐ Robotics & Industrial Controls
- ☐ Video Electronics Servicing
- ☐ Electronic Design Technology
- ☐ Digital Electronics
- ☐ Data Communications
- ☐ Communications Electronics
- ☐ Industrial Electronics
- ☐ Basic Electronics
- ☐ Telephone Servicing
- ☐ Small Engine Servicing
- ☐ Appliance Servicing
- ☐ Automotive Servicing
- ☐ Air Conditioning, Heating, Refrigeration, & Solar Technology
- ☐ Building Construction
- ☐ Locksmithing & Electronic Security

Name (Please Print) ______ Age ______

Street ______

City/State/Zip ______

Accredited by the National Home Study Council

20-026

More Details? CHECK—OFF Page 110

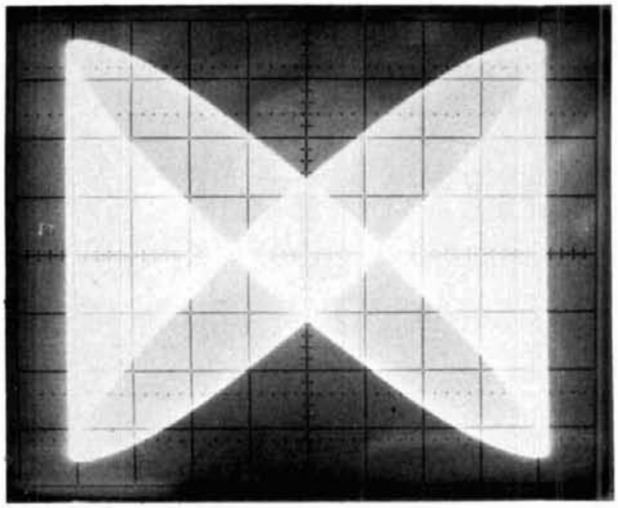


fig. 3. Bow-tie pattern before adjustment of phase control.

for the modulator and 0.146 Hz for the LED "on" indicator. The LED flash provides a visible indication of the operation, yet avoids the 10- to 20-mA drain of a steady lamp.

theory, analog section

R5, C5, R6, and C6 provide two poles of lowpass RC filtering to reproduce a near sine wave of 1800 Hz. I've found that when converting a fixed frequency square wave to sine that multiple RC lowpass sections, operated well beyond cutoff and followed by an op amp to recover gain, is simple and effective. In this case, very low distortion is needed so U4B is configured as a multiple-feedback bandpass filter. U4A is set up similarly, but for the 600 Hz channel. The series resistors in the RC sections may have to be changed slightly to adjust for equal gain through each channel and/or set the output of the bandpass filters

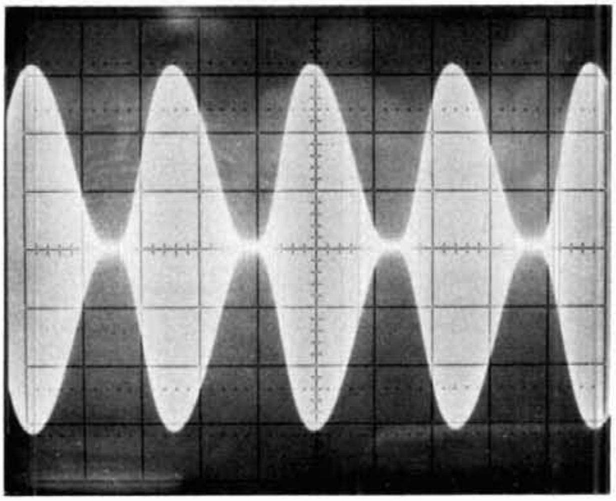


fig. 4A. Severe crossover distortion, standard position.

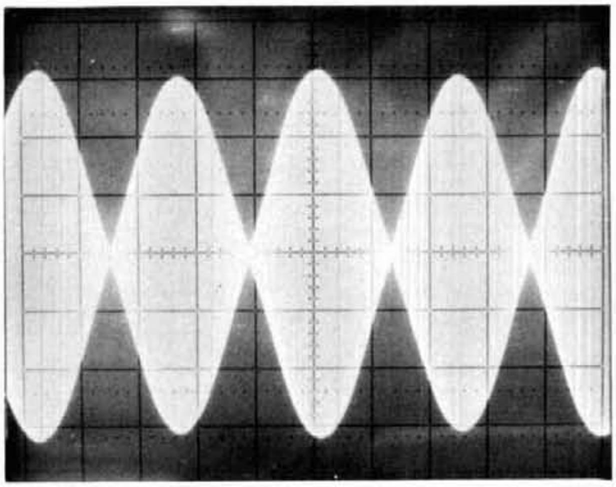


fig. 5A. Minor distortion, higher levels emphasized, standard pattern.

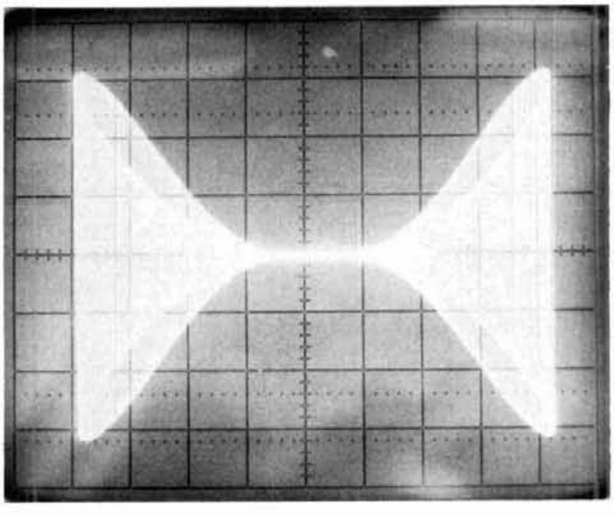


fig. 4B. Severe crossover distortion, bow-tie pattern.

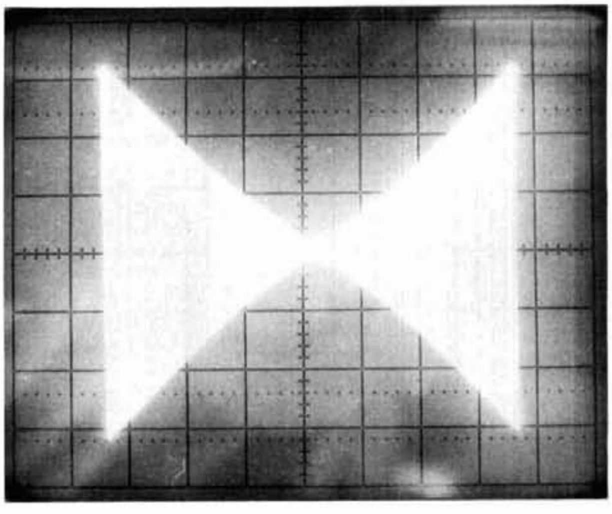


fig. 5B. resulting bow-tie pattern.

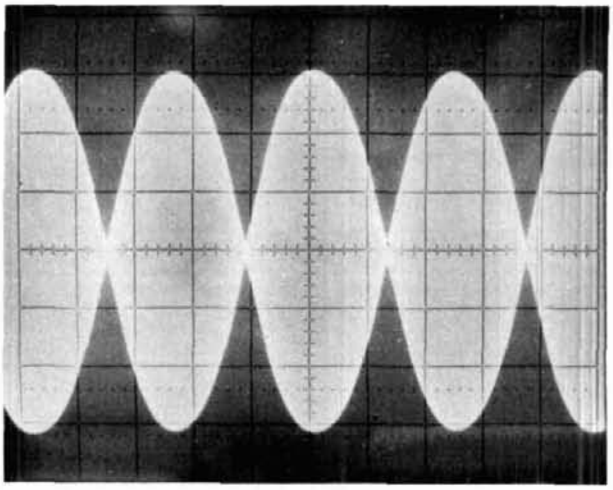


fig. 6A. Minor distortion, higher levels deemphasized, standard pattern.

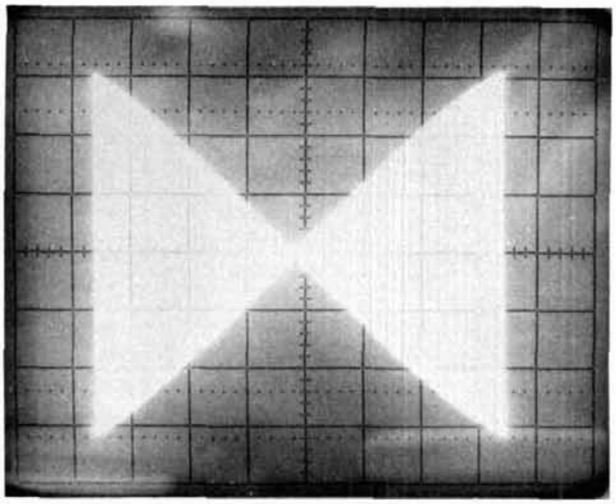


fig. 6B. Resulting bow-tie pattern.

to approximately 1 volt RMS. Both signals are mixed together at the balance potentiometer and go to the the transmitter through a voltage follower, U4C, and the level control. Up to this point, the circuit is similar to any conventional two-tone generator.

To obtain the "bow tie" pattern, the low tone must be sent to the X channel through a phase shifter to compensate for phase shift in the transmitter. U4D inverts the 600 Hz tone and feeds one side of phase shift network C13 and potentiometer R2Ø. Nearly 360 degrees of phase shift is possible. Voltage follower U5B presents a high impedance load to the output of the phase shift network and drives the scope isolation transformer, T1. Note that the secondary of T1 is kept floating from the chassis. Without DC isolation, severe problems with ground loops often occur. Care must also be taken with oscilloscopes that have a simple X input because they can be easily overdriven by the several vǫlts available at the scope output. A 500-ohm to 500-ohm transformer could be used as well.

To provide the modulated function, the 75 Hz square wave is converted to a near sine wave by three poles of RC filtering followed by gain recovery stage U5A. The 75 Hz signal enters the AGC input of U6, varying the output at a 75 Hz rate.

construction

I built the prototype using perf board, IC sockets, and point-to-point wiring using 30 gauge wire. Later I made a circuit board. Either way works fine. In the unit shown (see photo 1), I used some exotic dual-section pots with push-pull switches from my junk box, but normal pots will work just as well. I also added an extra 9-pin plug to allow the use of individual adapter cables to various transceiver microphone inputs and a switch to key the transmitters on. The case, battery holder, and switches came from Radio

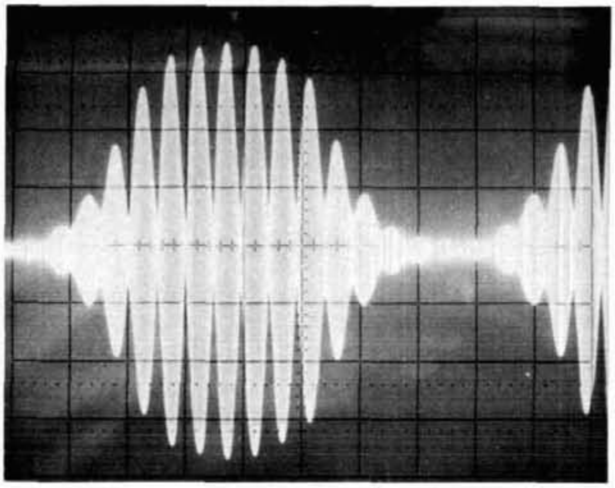


fig. 7. Pseudo voice pattern using "Modulated" functions.

Shack. Mylar capacitors should be used in the filter sections and the phase shift network. The 0.1 μF capacitor shown in the power supply line should be placed directly across pin 16 and 8 of U1.

alternatives

One alternative that might be tried is using a 32 kHz watch crystal. In this case, R1 should be changed to 10 Megohms and R2 to 680 or 750K. Only four stages of binary division would be required to produce 4096 Hz at the input of U2A, resulting in input tones of 2048 Hz and 682.66 Hz. The TL084 and LM353 ICs were used because they produce very little distortion. An LM324 and an LM348 could be used if resistors were added from the output of each amp to either ground or V_{cc} to cause the IC to always supply current in one direction. The crossover glitch is very visible on a sine wave. Don't omit the load resistors on the transformers; if you do, significant distortion will result.

More Details? CHECK—OFF Page 110

✓ 149

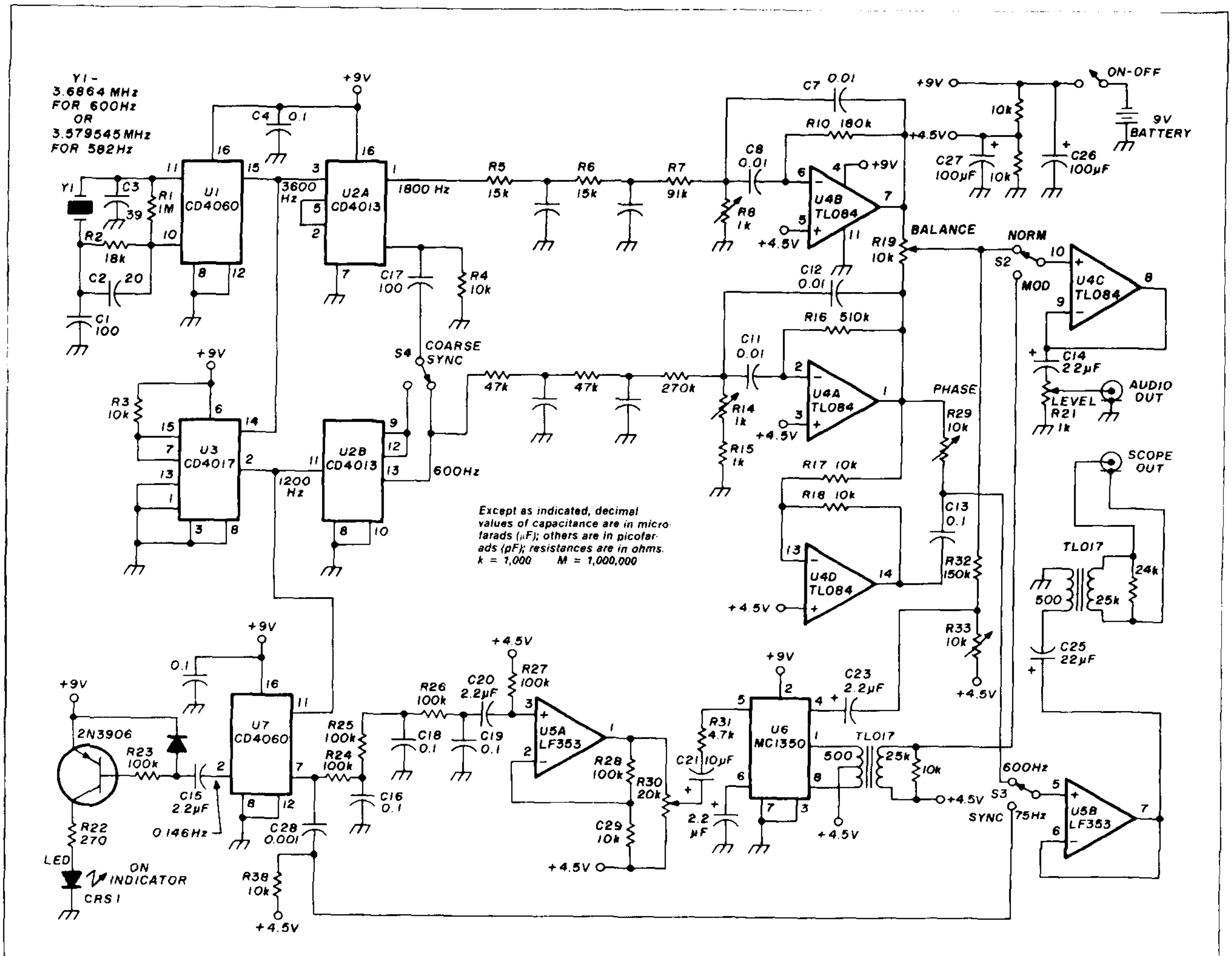


fig. 8. Schematic of two-tone test generator.

If you want to operate the two-tone test generator from an external AC or DC supply, or to ground the case to some external test equipment, an isolation transformer must be added to the audio output. In this case, T1 would not be needed, and the scope could be driven directly from voltage follower U5B. I tried this in one case and it worked fine. Again, don't forget to to terminate the transformer correctly! The power supply can be anything from 8 to 14 volts but must have very low ripple. I would recommend a three-terminal regulator in this case.

testing the circuit

Plug in the digital ICs. Use some form of current limiting in the power supply — to begin with, a 10-ohm resistor in series with a battery or a current limiting power supply. Turn the unit on and determine that normal current is flowing. Check for 3600 Hz, 1800 Hz, 1200 Hz, 600 Hz, 75 Hz, and 0.146 Hz at the places shown. If the lamp begins to flash every 5 seconds or so, then you can be sure most of it is working.

Plug in U4 and U5. Place a scope probe at the output of the 1800 Hz sine wave generator, U4B, and adjust R8 for maximum. Approximately 2 volts peak-to-peak should be present at this point. If the level is too high, causing distortion, and everything else checks out, increase the values of R5 and R6. In the same way, check out the 600 Hz sine wave generator. Move the scope to the output connector. Look for about 2 volts peak-to-peak of combined 600 Hz and 1800 Hz as the balance control is varied (with level at maximum) and for normal operation of the level control. Check at the output of U5A for a 75 Hz sine wave.

Put the scope on the output again, adjusting for 1800 Hz only. Put the S2 in the "mod" position and adjust R33 and R30 to produce approximately 100 percent modulation of the 1800 Hz tone with a peak level equal to the level in the "normal" position. Some interaction is present between these two controls, so several adjustments may be necessary. Turn the balance control for only a 600 Hz tone and check for approximately the same peak voltage in the "mod" and "normal" positions. The only glitch I've noticed in building several units is a tendency to oscillate when the level control is set at maximum. This occurred on a unit that used ribbon cable to connect the controls to the PC board, and since the level control is rarely at maximum in operation, I decided to ignore it.

conclusion

A two-tone generator with a "bow tie" pattern makes it easy to check linearity in an SSB transmitter. In fact, I found I had to be careful because I ended up trying to correct linearity problems that were normal to the equipment! But on the whole, it has made SSB servicing much easier and is certainly less expensive than a spectrum analyzer.

ham radio

SHORT CIRCUIT HOTLINE

Building a current *ham radio* project? Call the Short Circuit Hotline any time between 9 AM and Noon, or 1 to 3 PM — Eastern time — *before* you begin construction. We'll let you know of any changes or corrections that should be made to the article describing your project.

(See "Publisher's Log," April, 1984, page 6, for details.)

603-878-1441

PRACTICALLY SPEAKING ... Joe Carr K4IPV

troubleshooting II: solid state circuits

Last month I discussed methods for isolating the dead stage in a radio receiver. These methods — signal injection and signal tracing — are capable of showing us which stage is bad, and from there we can do further troubleshooting to isolate the faulty component.

In this installment, we'll look at another method that I learned more than two decades ago when solid-state car radios first appeared on the market. This method uses a DC voltmeter to isolate the faulty stage. It's not foolproof, but is well suited to many applications — especially when combined with other methods.

First, let's look at **fig. 1**. Here we have NPN and PNP transistors. In most amplifier circuits the base-emitter voltage will be 0.2 to 0.3 volts for normal germanium transistors (used in older equipment) and 0.6 to 0.7 volts for silicon transistors. In a PNP transistor the base is more negative than the emitter, and in an NPN transistor the base is more positive than the emitter.

Further, the collector will be more positive than either base or emitter in NPN transistors,* and more negative in PNP transistors. Keep in mind that the term "more negative" can mean "less positive" in some cases. I know that's confusing, so let's try to clean it up. Consider **fig. 2**. Here we have a cascade chain of three stages in a radio receiver. Each stage consists of a PNP transistor that's powered from a positive DC power supply. The collectors of the transistors are near ground potential, while the emitters and bases are closer to the + 10.5 volt "B + " line. If you measure the collector voltage with respect to ground, you'll find it very slightly positive, while the emitters are at a much higher potential. Thus, the collector's being less positive "causes it to perform as if it were negative."

Voltmeter "A" will measure the potential between the points being measured (in **fig. 1**, an emitter) and ground. If the voltage is near normal at each stage, then we can assume that there are no massive short circuits — but we can't get a hint of whether the stage is working properly.

Voltmeter "B" is connected with its positive electrode on the B + distribution line, and the other used to probe the emitters of the stages. The B + line can often be located from the service manual, but in some cases you'll have to fake it. Look for the electrolytic "filter capacitor" used to decouple the B + line (C1 in **fig. 2**). This filter capacitor will denote the proper line (unless you accidentally selected C2!), and usually has enough of a tab to allow connection of the voltmeter probe.

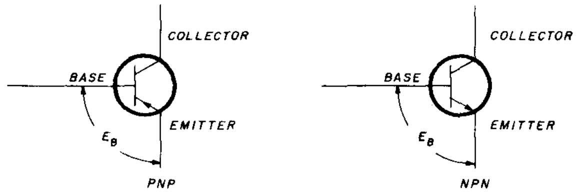


fig. 1. Specific voltage drops across base-emitter and collector-emitter junctions help determine if the transistor is functioning.

The voltage drop across the emitter resistor of each stage indicates the current conduction of the stage. If the service manual does not give the normal voltage drop, then calculate it from the emitter potential printed on the schematic and the B + voltage. In the case of the IF amplifier of **fig. 2**, for example, the emitter voltage is 9.1 volts, while the B + voltage is 10.5 volts. The normal conduction of this stage will be indicated by a voltage drop across the resistor of 10.5 − 9.1, or 1.4 volts. Any radical departure from this value indicates a problem. For example, a shorted transistor would send that conduction voltage (across R3) up to near 10 volts, while

*If the transistor stage is in saturation, the collector voltage will drop *below* the base voltage — i.e., $V_{CE_{SAT}}$ and $V_{BE_{SAT}}$

a leaky transistor would place the voltage somewhat lower but still larger than 1.4 volts. Similarly, an open emitter (or other condition that cuts off the stage) will reduce the voltage across the emitter resistor to nearly zero.

We can isolate the defective stage by looking at each emitter voltage in turn. Most often, the defective stage will show up from an anomally in the emitter conduction voltages.

Radios with NPN transistors in the stages are similarly treated. **Figure 3** shows a radio with NPN transistors powered by a positive-to-ground DC power supply. The collectors of these transistors will be close to the B+ potential, while the emitter and base voltages will be a lot lower. The values shown in **fig. 3** are typical, but they are not to be held as absolute (there are a lot of design choices that could alter the values, so buy and consult the service manual for your rig).

As in the case of the PNP stages, the NPN emitter conduction voltage denotes stage activity. In this type of circuit, however, the reference is ground instead of the B+ line. The principle is the same, however. We can check each conduction voltage in its turn and determine whether any of them are off. Fortunately, there are fewer calculations to make in this type of circuit. The emitter voltage on the schematic is the conduction voltage.

Both of the methods discussed above assume that there is a positive with respect to ground DC power supply. This arrangement is used in all modern American automobiles, so will be found typically in mobile rigs. In home rigs the DC power supply is often the same positive with respect to ground as shown here, but that is not necessarily so. It might be the case that the power supply is negative with respect to ground, or that there are two power supplies (one positive to ground and one negative to ground). The principle in these cases are the same, only the point of voltage reference will change.

Variable frequency oscillators, whether in a receiver or transmitter VFO, will behave a little differently. In most cases, the DC conduction of the oscillator transistor varies with frequency setting. Typically, the voltage will be higher at the low end of the band, and lower on the high end of the band (with a smooth transition as the dial is tuned). A sudden discontinuity in this transition might indicate a sud-

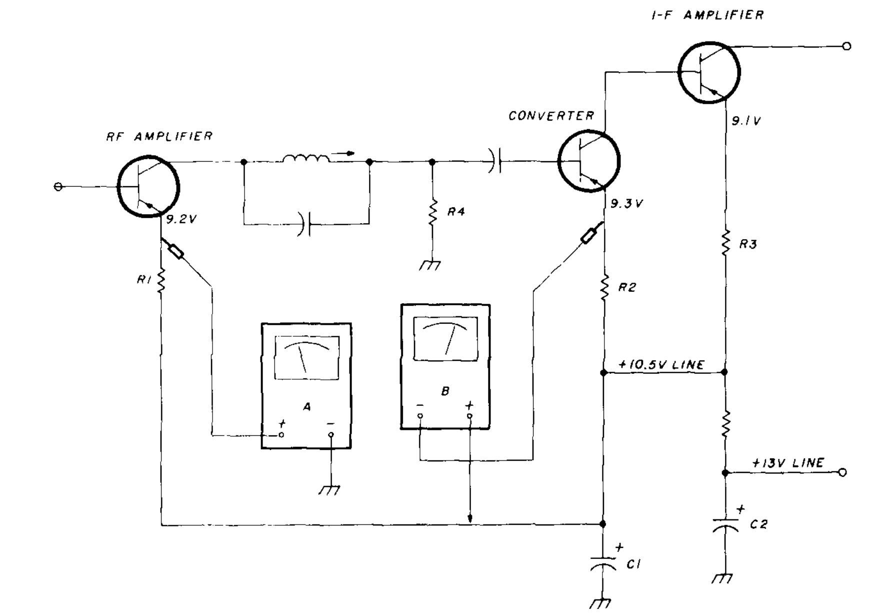


fig. 2. Voltage drops across the emitter resistors determines if the PNP transistors are operating properly.

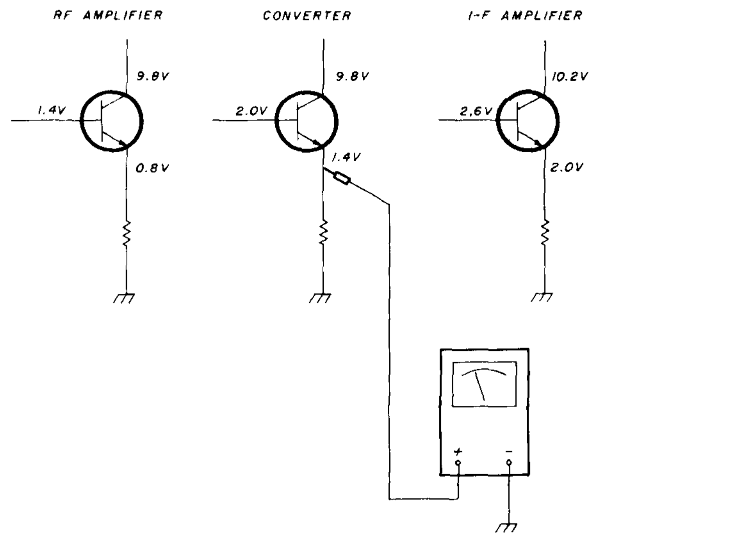


fig. 3. With NPN transistors, emitter resistor voltage drops are usually determined just by measuring the emitter voltages (with respect to ground).

den cessation of oscillation (or a parasitic developing) at that point on the dial.

Crystal oscillators behave in a similar manner. If the crystal selector switch is changed, then the voltage can be expected to change also. If the crystal is removed, then the voltage will usually change radically.

By the way, don't remove crystals willy-nilly. In some cases, especially when the next stage is a grid-leak biased vacuum tube power amplifier, damage might occur to the equipment.

an ambiguous case

There are three ways to stage isolate a dead radio receiver. In part I of this two-part series, we reviewed signal injection and signal tracing and in this article we discuss using a DC voltmeter to find the defective solid-state stage. But some situations are not as clear.

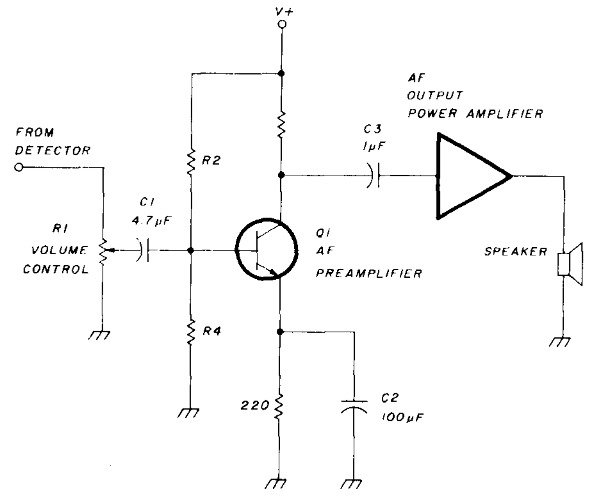


fig. 4. Loss of gain in audio stages can sometimes be attributed to an open emitter bypass capacitor.

Consider **fig. 4**. This circuit is a simplified audio section, with only the preamplifier shown in detail. The combination of AF preamplifier and output power amplifier may be capacitor coupled (as shown here), direct coupled or in the form of a single integrated circuit housing both stages. The symptom is weak reception. All stations are heard, but at very low volume. If you read last month's article, you'll recall that this symptom generally points to the output IF amplifier, detector or audio stages; but in this case, it's the audio stage that contains the fault.

I've seen a lot of cases where the DC voltages on Q1 were normal and there seemed to be adequate signal passing through the stage regardless of whether signal injection or tracing was used. The ambiguity will show up except in the very special case where the sensitivities and impedances of the signal generator and signal tracer are matched to the particular equipment being serviced (some "radio analyst" instruments used by commercial servicers fall into this category).

In the event that this ambiguity shows up, jump on capacitor C2. This capacitor is used to place the emitter of Q2 at or near ground potential for AC while retaining the DC bias on the emitter. If this capacitor opens up, the gain of the stage will go down one heckuva lot without (usually) affecting the DC voltages. Turn the rig off, solder tack a replacement capacitor across C2 (the exact value isn't critical — anything ±200 percent of the correct value will do for the test). Turn the rig on. If the output volume comes up a lot, then mark C2 for replacement.

I don't know why it is, but this problem seems to keep popping up. I've seen it in varying degrees in car radios, home radios, Amateur radios, CB radios and commercial two-way radios. It also turns up in vacuum tube equipment.

Old Gear Restorer's Note: If you restore an old Heath DX-60B (or other older transmitter) and find the RF output intermittent as the rig is keyed, then look to the plate circuit of the crystal oscillator. This circuit is a modified Miller oscillator, and has a slug-adjusted inductor in the plate circuit. When the rig is stored, unused for several years, the core of this coil will change characteristics, and the oscillator will refuse to oscillate reliably. I scratched my head over two of these rigs last year and finally stumbled on the answer. While keying the rig, carefully adjust the slug until reliable operation occurs (as indicated by a lightbulb dummy load or RF wattmeter), then give it another turn or so.

Incidentally, similar circuits are used in a lot of older ham gear, both vacuum tube and solid state, HF and VHF. Anytime you have a piece of equipment with an oscillator of this type that seems to operate intermittently or unreliably, and everything else seems to check out, then consider adjusting the coil.

Normally I don't recommend "diddlestick" troubleshooting — to the extent of hollering "NEVER!" when someone suggests it. One of the few possible exceptions might be in equipment that has been unused for many years, and contains ferrite core coils in oscillator circuits. I still maintain that sudden failures in equipment that has been working should be regarded as a component failure, not as an alignment problem so in that case, leave the darned diddlestick in the toolbox!

ham radio

the offset drooper
an improved ground plane

Reduce antenna effect and still achieve a 50-ohm feedpoint resistance

The original "ground plane" omnidirectional antenna was developed in the late 1930s jointly by Dr. George H. Brown, J. Epstein and R. F. Lewis, W2EBS, all of RCA Laboratories. It consists of the long-familiar configuration of a vertical quarter wave "spike" working against four resonant radials at 90 degrees to the mast. In the original version, patented in 1941, the feedpoint impedance is matched to the coaxial feedline by means of a quarter wave coaxial "Q" section. A typical Amateur adaptation is shown in **fig. 1**. In 1942 Dr. Brown patented, solely, the version shown in **fig. 2**, which has several advantages over that of **fig. 1**.

These basic "ground plane" antennas exhibited less antenna effect (surface current) on the mast and feedline than did other omnidirectional VHF antennas widely used at the time. However, the four radials at 90 degrees to the mast are somewhat "transparent" and definitely resonant. For this reason they may be considered more a part of the antenna than a virtual ground plane for the "spike." Semi-infinite ground plane characteristics would allow little radiation below zero degrees elevation. Such a pattern might be unsuited to a mountain top location or a swaying freestanding mast.

Because of the direction of current flow in the radials, the resultant radiation from the individual spikes results in good cancellation, and there is little net radiation from them. The fact that one may touch the tip of one radial with little effect on VSWR doesn't mean that the radials do a good job of simulating a large, flat conductive sheet. Because of the quarter wavelength of the radials, pinching the tip of one elevates the impedance at the opposite end and effectively isolates it. The remaining three radials simply take over, with only moderate detuning of the antenna.

The result of all this is as follows: the performance of a "90 degree" ground plane represents an improvement over several previously popular base station antennas. However, while orienting the resonant radials at 90 degrees does reduce inductive coupling to the coaxial line and mast, it doesn't effectively eliminate it. The coupling is sufficient that the resulting antenna effect may be found undesirable for some applications.

Long popular among hams for VHF and upper HF is the "droopong" ground plane, a simplified, less elegant, low-cost descendant of the Brown ground plane. Simply bending down the horizontal radials to about 45 degrees raises the radiation resistance to 50-52 ohms. This permits direct connection of the coax without use of a matching device. A more appropriate description might be "skeleton skirt dipole," because the resonant drooping radials don't do a very good job of serving as a virtual ground plane. Instead, they exhibit more inductive coupling to the feedline than do radials at 90 degrees.

Nearly 40 years ago, in the *Antenna Manual*, I pointed out that while the drooping ground plane or "drooper" is simple and works well, the configuration aggravates antenna effect. For the benefit of those not familiar with the term, *antenna effect* (transmit case) can be described briefly as follows:

Antenna effect on a two-wire line: refers to line radiation as a result of "common mode" current. Part of the power (energy) fed to the feedline travels on it as though the two wires were tied together and were working against ground. Usually it results from load imbalance and/or excessive coupling from one side of a balanced antenna to the line. Common mode current adds in one wire and subtracts in the other. This in-phase component of the total power fed to the line acts as though the two wires were in parallel. So it gets radiated.

Antenna effect on a coaxial line refers to radiation from a coaxial feedline as a result of current flowing on the outside of the outer conductor. The current often is shared with the surface of a metal mast supporting a bottom-fed vertical antenna. Usually it results from either or both of the following:

• The outer conductor of the coax is directly connected to a point on the antenna not precisely at

By Woodrow Smith, W6BCX, P.O. Box 2898, Anaheim, CA 92804

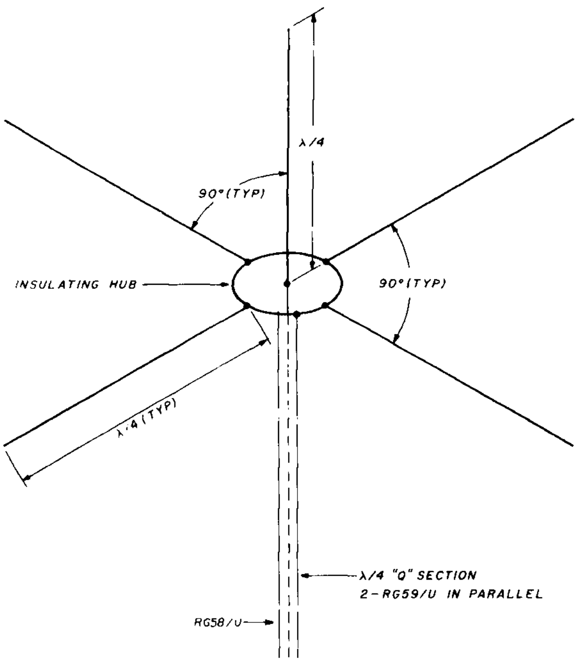


fig. 1. Typical Amateur adaption of the classic (original) Brown ground plane antenna, suitable for upper HF use on a flat roof, or for upper VHF use on a mast.

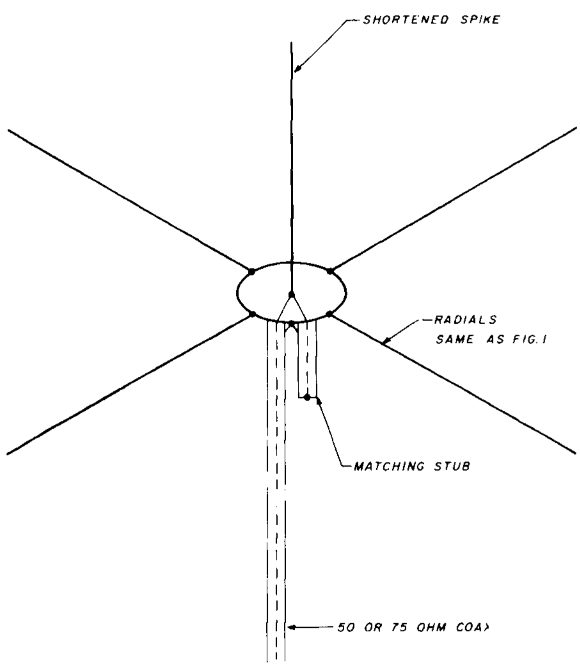


fig. 2. A later version by Brown eliminates the Q section and allows easy tweeking for a perfect match at a spot frequency. Useful where the antenna must be side-mounted on a shared mast of large cross section, or is other wise subjected to unpredictable detuning.

ground potential. As a result, current flows not just to the antenna, but is encouraged to flow back down the *outside* of the coax shield to a virtual ground as well. The "ground" can be a cabinet at VHF or house wiring at HF, for example.

• Excess inductive coupling exists from one half of the antenna to the outside of the coax or metal supporting mast (or both). The radials of a drooping ground plane are a case in point. If the coax is enclosed by a metal mast, spurious current flows on the surface of the mast. If the coax is draped along the outside of a metal mast, current flows on the surfaces of both and *both* radiate. To complicate things, the mast can have its own virtual ground.

is antenna effect all that devastating?

At just what point antenna effect becomes serious enough to be concerned about is debatable. The amount of current that can be tolerated on the outside of a coax line or mast or both depends to a great extent upon the following:
On transmit, let's first consider a well elevated, vertically polarized, omnidirectional VHF antenna with a feedline many wavelengths long. What is the result of antenna effect? Normally little of the power (energy) radiated with vertical polarization from such a long feedline (and the mast) will be directed at the horizon. For this reason, little of the spurious radiation will either add to or subtract from the energy being radiated effectively towards the horizon by the antenna proper.

So at VHF the end result of antenna effect on *transmit* is primarily a waste of power. But even if as much as 20 percent of the total radiated power is radiated by the coax, mast or both and thereby wasted, the resulting 1 dB loss is hardly anything to get worked up about. This is especially true when it buys worthwhile simplicity, convenience, or economy. However, if the radiating coax passes close to a TV receiver feedline, TVI may result if the TV coax suffers from poor shielding, or if the TV twinlead feeds a poorly balanced receiver front end.

On *receive*, the situation is different. Consider a coax line running through a localized area of high ambient noise. Antenna effect can cause noise picked up by the outer conductor of the coax to travel up to the antenna proper, then back down the coax to the receiver input just like a desired signal.

baluns vs. resonant isolators

Baluns of the type used with HF dipoles to minimize antenna effect are not suited for use with vertically polarized VHF antennas of the omnidirectional type. Instead, resonant detuning sleeves, cones, and radials are widely used as isolators or decouplers to "cool off" the mast and feedline. To what extent these produce any practical benefit in a particular installation by reducing antenna effect often is open to question. The use of coiled coax, ferrite beads, or a ferrite sleeve to choke off or dissipate surface current on the coax does not solve the metal mast problem.

Granted, no startling increase in transmitted signal strength will be noted when a resonant isolator of some kind is added to a simple VHF drooping ground plane. But even so, suppose it were possible to achieve a big reduction in antenna effect on the drooper without adding a resonant isolator. Suppose the various resulting advantages (such as they are) could be achieved by simply altering the dimensions and the droop angle.

something for nothing?

It's not only possible; it's *simple*. And there are no additional parts or materials, and without any additional manufacturing, construction, or assembly labor. Here's how: take the case of a conventional drooper that's supported by a metal mast enclosing the coax. Current is induced on the mast as a result of inductive (mutual impedance) coupling to the radials. If the coax exits the hub external to the mast (offset antenna mount), spurious current also appears on the outside of the coax.

This detrimental inductive coupling can be reduced somewhat by reducing the droop of the radials (the angle they make with the horizontal). The remainder can be compensated for by deliberately introducing a critical amount of conductive coupling of opposite phase. This is done by drastically offsetting the feedpoint from the voltage node.

The offset required for good cancellation is accomplished by simply making the radials as much as 30 percent (yes, thirty percent!) longer than the spike. Because precise cancellaton is somewhat frequency-sensitive, the effectiveness will vary a bit over the 2-meter band. However, in spite of the fact that optimized coupling neutralization is less than perfect over the whole band, the practical results obtained are most worthwhile.

Offsetting the feedpoint from the voltage node raises the feedpoint resistance. On the other hand, lessening the droop angle lowers the feedpoint resistance (by lowering the radiation resistance). By proper choice of these two values, it's possible to reduce antenna effect dramatically while at the same time achieving a 50-ohm feedpoint resistance. With an offset represented by a 28-30 percent radial-to-spike length differential, a 27-29 degree droop angle provides both maximum reduction in antenna effect *and* a 50-ohm feedpoint resistance. To some extent the optimum values vary with conductor diameter, mast diameter, and hub geometry. Less important is whether the coax departs the hub inside or outside the tubular mast.

Neither the 1.5 VSWR bandwidth nor the antenna gain is noticeably degraded by drastically offsetting the feedpoint and reducing the droop of the radials. And in case you're skeptical about the horizon gain comparisons, it's true that the spike is slightly shorter on an offset drooper. Likewise, the resultant vertical component or vector of the drooping radials is a little shorter for an offset drooper than for a regular drooper. But careful measurements show this does not affect the gain significantly. Increased current throughout the antenna resulting from the lower radiation resistance (about 35 ohms) compensates. Also, power wasted by line and mast radiation is reduced to insignificance.

Out of curiosity, a check was made to see just what would happen if the feedpoint of a classic 90-degree ground plane were deliberately offset. When the resonant radials were lengthened, an arbitrary 12 percent and the spike length and matching adjustment were re-optimized, antenna effect was virtually eliminated. However, overall performance was no better than that of an offset drooper, which has the advantage of requiring no matching device. Because of the latter, no further work was done with 90 degree ground planes. It is interesting to note that when resonant radials at 90 degrees to the mast were shortened experimentally by no more than a few percent, antenna effect was markedly aggravated.

improvement over what?

A check was made on drooper dimensions given in various handbooks and past magazine articles. Also, two different commercially manufactured 2-meter droopers were purchased and the dimensions measured. The effective radial length ranged from slightly longer than the spike to slightly shorter. All were series-fed at the hub without benefit of a matching device. None employed a resonant decoupler, such as an extra set of radials below the antenna oriented 90 degrees to the mast.

The reduction of antenna effect provided by drastically offsetting the feedpoint of a drooping ground plane depends, among other things, upon how bad the antenna effect is to begin with. This varies somewhat with location of the voltage node on the regular drooper used for comparison. For instance, antenna effect definitely will be worse if the radials of a regular drooper are significantly shorter than the spike, as was the case with one of the name brand antennas tested. This makes an offset drooper appear just that much better by comparison.

a spurious top-fed Marconi is the culprit

The degree of improvement will also vary with the length of the coax. This is explained as follows: the

✓ 118

outside of the coax shield will do its best to act like a "harmonic Marconi" fed at the top instead of the bottom. Just how effective (and therefore how objectionable) this is will depend to a great extent upon the electrical length of the coax shield in wavelengths from "virtual ground" to the point of attachment to the radials.

Unfortunately, with 40 feet of coax, QSY from 144 to 148 MHz can change the electrical length of the shield substantially. This in turn affects the feedpoint impedance of the spurious "upside down harmonic Marconi." The variation can affect the amount of line radiation by 10 dB or more in the case of a conventional drooper. Things get even more involved when comparing an offset drooper to a regular drooper for antenna effect simply by swapping them at the end of the same feedline. The radials of a 2-meter offset drooper are longer than a quarter wave and their impedance to ground at their feedpoint therefore is affected. This was taken into account when designing the antenna and making comparison measurements.

the test set-up

For reference, a 2-meter drooper with optimized offset feed was constructed with four radials 30 percent longer than the spike and having a droop angle of 28 degrees. For starters for those who might like to experiment, the 1/8 inch diameter spike measured 18 3/8 inches and the 3/32 inch diameter radials 24 inches, all of brass welding rod. Size and configuration of the hub will affect the lengths, especially that of the spike. Note that while the spike of an offset drooper is only slightly shorter than normal, the radials are much longer. The result is that the overall length of the spike plus a radial is nearly 10 percent longer than for a conventional drooper. This involves the integral coupling neutralization and impedance transformation process, and a rigorous explanation is not within the scope of this article.

The offset drooper reference antenna just described was compared to four different conventional 2-meter droopers for antenna effect, 1.5:1 VSWR bandwidth, and field strength at zero elevation angle. One of the conventional droopers was constructed to dimensions specified in a magazine article. Two were dissimilar name brand units. None employed a detuning sleeve, cone, or extra set of radials. Measurements were taken near 144, 146, and 148 MHz with four feedline lengths differing by 1/8 wavelength.

Tests were first run with the coax leaving the hub contained within a 3/4 inch O.D. mast for the first 5 feet. The tests then were repeated with the hubs offset from the top of the 5 foot upper mast section. With the hubs offset, the coax was brought down snugly against the outside of the mast for its entire length. Next, the hub was mounted concentrically atop a 12-foot section of aluminum tubing strapped to a steel vent pipe, with the coax brought down inside the tubing. While these changes did cause the readings to change, the overall improvement exhibited by the offset drooper did not change significantly. The coax employed was RG/8X-8M 0.25 inches OD, 52 ohm.

test results

A spurious RF current sniffer was improvised to quantify the amount of improvement exhibited by the offset drooper. The sniffer was provided with a plastic spacing fixture that allowed choice of two spacings in order to increase the useful range. It was checked for directional effect (by reversing it) and the directivity was found to be negligible. Relative calibration in dB was accomplished by simply varying the measured power fed to a leaky dummy load which was space-coupled to the sniffer.

The reduction in antenna effect when using the offset drooper exceeded 11 dB for three of the comparison antennas tested. The improvement obtained over the fourth regular drooper (the one with the longest radials) measured 10 dB. The greatest improvement was observed when the offset drooper was compared to the regular drooper having the shortest radials (about 5 percent shorter than the spike). The improvement figures reflect those obtained or exceeded with the worst case combination of frequency, line length, and mast and feedline configuration.

This article is not intended to show the reader how to build something exactly like the author's, but instead to explain a simple method of improving the performance of the venerable drooping ground plane. Just make the spike a little shorter, the radials a lot longer and bend the radials up a bit. It is applicable to modification of existing antennas as well as to new construction. To approach the maximum possible improvement, all you need is a VSWR meter. Just make the radials 30 percent longer than the spike and droop them 28 degrees (or as close as you can). Optimum length for the spike is usually about 6 percent shorter than for a regular drooper that uses similar hub and element diameter.

If this doesn't result in equal VSWR at the band edges, the spike is too long or too short. Once the radial length and droop are optimized, the center frequency can be fudged about 1 percent just by trimming the spike.

The reader will notice that no VSWR numbers are given for an optimum offset drooper. The reason for this is that a conventional drooper with bad antenna effect can give specious VSWR readings, making any offset drooper comparisons meaningless. The deceptive readings obtained with a standard drooper will change with coax and mast lengths, and the readings can be considerably better (or worse) than the true antenna VSWR. To a lesser extent this applies also to a classic 90 degree ground plane. But with an optimized offset drooper, readings will change little with line and mast lengths (except as reduced by line attenuation), and can be relied upon. The true VSWR of a properly optimized 2-meter offset drooper will approach 1.0:1 over much of the band, and be found very low at the band edges.

so why not?

In closing, I hope the reader accepts the fact that while a bad case of antenna effect on a VHF drooper isn't necessarily disastrous, minimizing it certainly can't hurt. It's easy to do and all it can do is good — so why not?

references

1. *Ground Plane Antenna*, U.S. Patent 2,234,333, issued March 11, 1941, to G.H. Brown, J. Epstein, and R.F. Lewis of RCA Laboratories.
2. *Improved Ground Plane Antenna*, U.S. Patent 2,275,342, issued March 3, 1942, to G.H. Brown.
3. Woodrow Smith, *The Antenna Manual*, Editors and Engineers, Ltd, Santa Barbara, California, 1948.

bibliography

Vance, Harold C., Sr., K2FF, "The Ground Plane Antenna: Its History and Development," *ham radio*, January 1977, page 26.

ham radio

109

✓ 182

VHF/UHF WORLD

Joe Reisert
W1JR

reflector antennas: part 1

The subject of reflector antennas in general and those of the parabolic dish type in particular generates lots of correspondence and requests for information. I never knew that any single VHF/UHF/ SHF antenna could be so much on everyone's mind — especially since so much material has already been written on the subject. Confusion seems to reign.

Since it began, this column has concentrated on providing solid groundwork in the lower frequencies; limits of time and space have not allowed discussion of more narrowly-defined topics such as specific types of antennas. But with last month's column, we launched a discussion of the microwave bands[1] so this would seem to be an appropriate time to address the subject of reflector antennas since they're so often used at UHF and microwave frequencies.

This discussion will be divided into two parts. Part I — this month's column — addresses the electrical aspects of reflector antenna design, including gain and specific parameters of the parabolic antenna. Part II — next month's column — will cover feed systems and the mechanical aspects of parabolic antenna design. With Parts I and II in hand, you should have all the required material and references necessary to design and build a first-class parabolic antenna.

reflector antenna types

Before discussing the parabolic dish, it should be interesting to review some of the more common types of reflector antennas. They include, but are not limited to, the cylindrical parabola, parabolic dish, corner reflector, backfire, spherical dish, and dual reflector types of antennas.

The *cylindrical parabola* (**fig. 1A**), believed to be the first RF-type of reflector antenna, was used by Heinrich Hertz in 1888! He illuminated a reflector with a spark-gap at about 66 cm (445 MHz) in an attempt to prove the existence of electromagnetic waves, which had been theoretically predicted by James Clerk Maxwell.[2] For best performance, the cylindrical parabola requires a line feed. (Thus was born the field of microwave optics.) An Amateur cylindrical parabola is described in reference 3.

Reflector antennas were soon eclipsed by the search for DX on the HF (high frequency) bands by Marconi and others. Thus it wasn't until the 1930s that serious work on reflector antennas got under way, primarily through the efforts of Grote Reber, ex W9GFZ, in his radioastronomy experiments. Reber used the parabolic dish type of antenna shown in **fig. 1B**. Properly designed, it focuses all the energy at a common point, which greatly simplifies the feed system. Hence it is often referred to as a prime focus-fed antenna.

The corner reflector, as depicted in **fig. 1C**, was invented by Dr. John Kraus, W8JK, in 1940.[4] However, it is limited to gains of up to about 15 to 20 dBi and is quite large relative to the gain delivered.

The *backfire antenna* was invented by Dr. Herman Ehrenspeck in 1958.[5] He discovered that if a Yagi antenna were aimed into a special reflector system and the Yagi structure properly retuned, its gain could be increased by 3 to 5 dB (**fig. 1D**). However, the backfire antenna never gained popularity because it required a large reflector with a special stepped surface.

Later Dr. Ehrenspeck designed the *short backfire antenna* shown in **fig. 1E**.[6] It's smaller and simpler, but its gain is lower (16 dBi is typical). However, it has gained popularity with the military, especially for portable VHF/UHF satellite operation.

At first glance, the *spherical reflector* looks very much like a parabolic dish. But it has a different reflector profile and is very difficult to feed because the energy is not focused on a common point, as in the parabolic dish. Instead, the energy is present along a line, and a special phased line-source feed is required to properly phase the energy.

Because of its shape, the spherical reflector beam can be partially aimed by simply moving the feed system. This allows the beam to be steered off boresight by up to several times the antenna beamwidth, with little or no performance degradation. Hence the spherical reflector antenna is often used in large structures where the reflector is stationary.

The largest and certainly most famous spherical reflector antenna is at Arecibo, Puerto Rico. Built in the crater of an extinct volcano, it measures 1000 feet (305 meters) in diameter, has a stationary reflector, and uses a special "scalar" feed that can be steered. At 430 MHz, this feed is over 96 feet (28 meters) long![2]

Other antenna systems use a secondary reflector that allows the feed system to be placed at a more convenient point in the structure (see **fig. 1F**). Examples are the *Gregorian*, *Cassegrain*, and *Newtonian* fed-reflector antennas. There are many other variations of the antennas just described.[2,7,8,9] These variations are associated with the different feed system employed.

The implementation of a secondary type of reflector is usually beyond the reach of the typical Amateur and beyond the scope of this column. The improvement obtained with such systems is often at the expense of considerable complexity, which can often be offset by designing a slightly larger antenna right from the start — certainly a typical Amateur approach!

tradeoffs

All types of reflector antenna systems have their advantages and disadvantages. The technical literature on reflector antennas could easily fill a good-sized room! (See references 2, 7, 8, and 9 for starters.) But for the Amateur, the parabolic reflector antenna that uses a prime focus feed system as shown in **fig. 1B** is one of the simplest antennas for obtaining high performance with relatively straightforward construction.

Some of the main advantages of the parabolic dish include its use of a single feed; its ability to operate on other frequency bands by simply exchanging the feed system; its low noise pickup — i.e., its clean radiation pattern. It has reasonable gain for the size of the aperture employed. Its disadvantages include large surface area, which leaves it vulnerable to damage

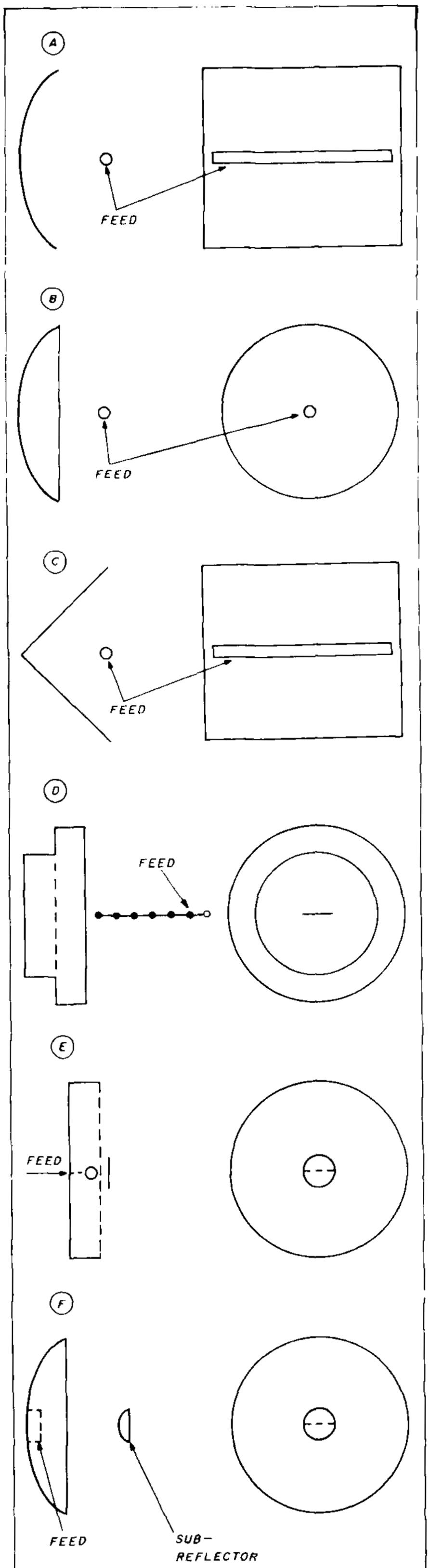


fig. 1. Some common types of reflector antennas. *A*) cylindrical parabola, *B*) parabolic reflector, *C*) corner reflector, *D*) long backfire, *E*) short backfire, and *F*) dual-reflector.

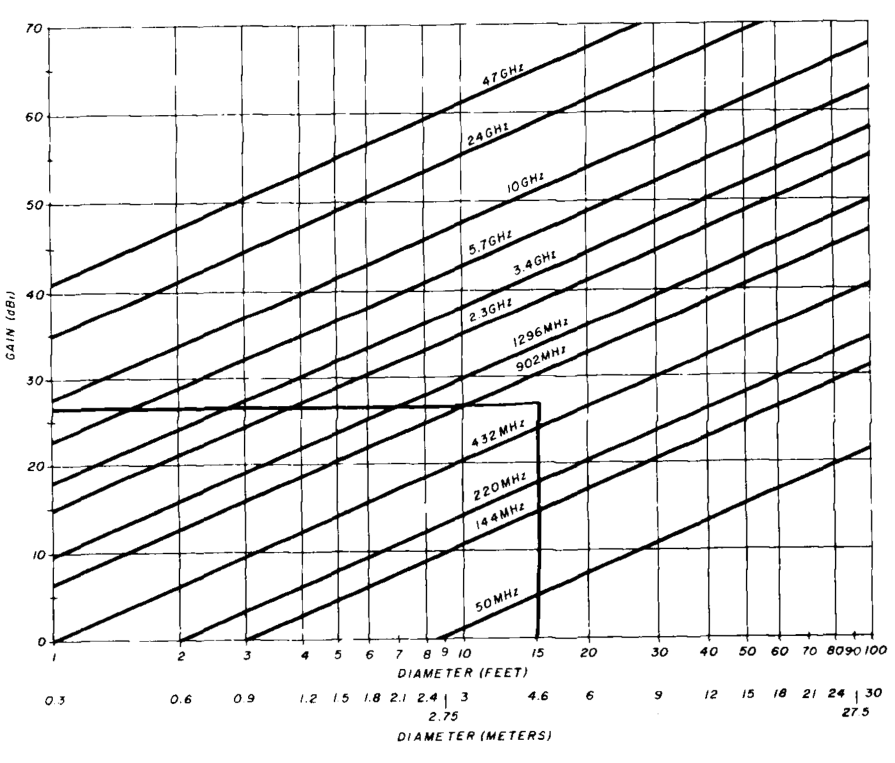


fig. 2. This graph is a plot of gain versus size for typical parabolic dishes with 55 percent efficiency.

from wind or snow; comparatively large physical size (for gain) than a Yagi array offering equivalent gain; and the mechanics involved in designing the reflector and rotation system, especially if it's used on EME. Despite these shortcomings, the parabolic dish, with its single feed system, is a natural for the UHF and especially the Amateur microwave bands.

gain and beamwidth

Generally speaking, the efficiency of a well-designed parabolic dish is in the range of 50 to 60 percent (more on this later). Hence it will have an effective aperture or capture area that is somewhat smaller than its physical area.[10]

Based on a 55-percent efficiency, a typical design standard, the gain of a well-constructed parabolic dish can be easily calculated using **Eqn 1**.

$$G = 10 \log [0.55 \cdot 4\pi A/2] = 10 \log (6.9A/2) \quad (1)$$

where G is gain in dBi and A is the area of the reflector. Both area and wavelength must be in the same unit of measure.

For example, the area of a 20-foot (6.1-meter) diameter dish is about 314 square feet (29.2 square meters). At 432 MHz a wavelength is 2.277 feet (0.694 meters). Therefore, using **Eqn 1**, the gain would be about 26.2 dBi.

You may prefer to work directly in feet/meters and frequency. If so, the following formulas can be derived from **Eqn 1**.

$$G = -52.4 + 20 \log D + 20 \log F \quad (2)$$

where gain is in dBi, D is dish diameter in feet and F is frequency in MHz or

$$G = -42.1 + 20 \log D + 20 \log F \quad (3)$$

where G is in dBi, D is dish diameter in meters and F is in MHz. **Eqns 2** and **3** yield the same gains as **Eqn 1** without having to first calculate the reflector area.

In order to make it easier to rapidly determine gain, I have prepared the graph in **fig. 2**, which includes practical size reflectors and gains of 10 to 70 dBi on most of the popular Amateur VHF/UHF bands. Note that in the example just described, the graph shows the gain to be about 26 dBi, very close to the calculated value!

Finally, it has been pointed out before in this column that as the gain of an antenna increases, the beamwidth decreases.[11] For a parabolic antenna, the beamwidth can easily be determined to a reasonable accuracy (*± 10 percent*) using the following formula:

$$BW \approx 70\lambda/D \quad (4)$$

where BW is in degrees and D is the reflector diameter. Both wavelength and diameter must be in the same unit of measure.

For example, the antenna just described has a diameter of approximately 20 feet (6.1 meters). One wavelength at 432 MHz is approximately 2.28 feet (0.694 meters) and 0.76 feet (0.231 meters) at 1296 MHz. Hence its beamwidth would be approximately 8

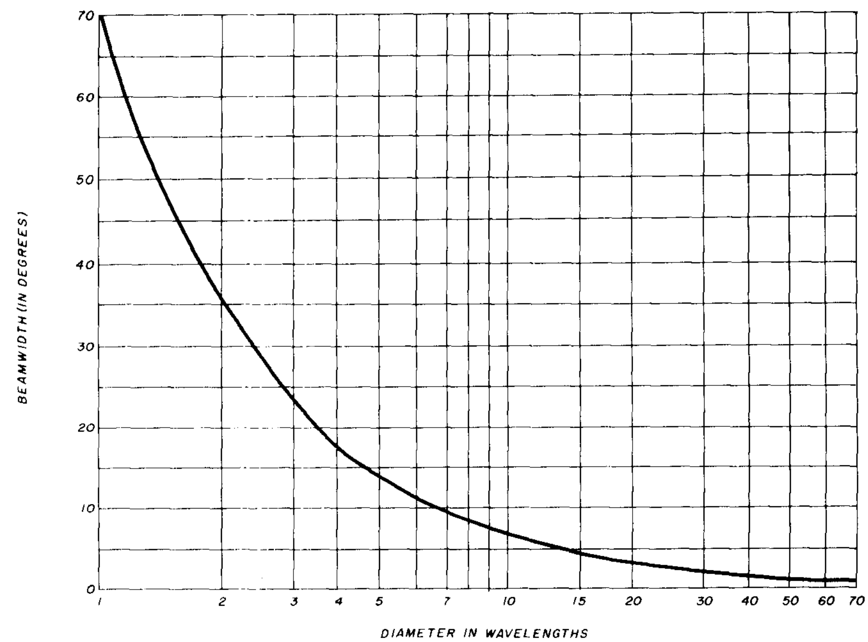


fig. 3. Antenna beamwidth versus parabolic dish diameter in wavelength.

table 1. Typical parabolic curve dimensions for a 20-foot (6.1 meter) diameter parabolic dish with a 0.5 f/d ratio.

distance from center of dish (Y)		depth of dish (X)	
feet	meters	inches	centimeters
1	0.305	0.3	0.76
2	0.61	1.2	3.05
3	0.915	2.7	6.86
4	1.22	4.8	12.19
5	1.52	7.5	19.05
6	1.83	10.8	27.43
7	2.13	14.7	37.34
8	2.44	19.2	48.77
9	2.47	24.3	61.72
10	3.05	30.0	76.2

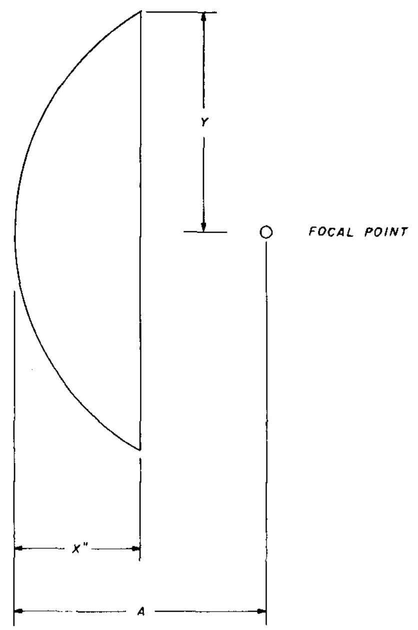


fig. 4. This figure shows the mechanical properties of a parabolic dish reflector.

degrees at 432 MHz and 2.66 degrees at 1296 MHz.

Properly designed, the parabolic dish has a symmetrical beamwidth the same in both E and H planes. The graph in **fig. 3** has been prepared to simplify beamwidth estimation.

design parameters

So how does one go about designing a parabolic dish? What tradeoffs are required? Where do you feed the dish?

First you have to understand the geometry of a parabolic dish. You must have a reflector that follows a parabolic curve. This is described mathematically by **Eqn 5** below:

$$Y^2 = 4AX \qquad \textbf{(5)}$$

where, referring to **fig. 4**, Y is the radius of the reflector, A is the focal length and X is the depth of the reflector, all in the same unit of measure.

If the diameter and focal point (as described below) are known, we can rearrange **Eqn 5** to a more convenient form as shown below:

$$X = Y^2/4A \qquad \textbf{(6)}$$

For instance, suppose that you want to design a 20-foot (6.1 meter) diameter parabolic dish with a focal length of 10 feet (3.05 meters). Using **Eqn 6**, the edge of the dish will be 2.5 feet (65 cm) higher than the center of the dish. Likewise, a point halfway from the center will be 0.625 feet (19 cm) above the center, and so forth. **Table 1** shows a typical parabolic curve for this example. With all the personal computers available, there are many kinds of programs to simplify the computation of a parabolic curve. References 12 and 13 will help you select such a program.

Finally, if the diameter and depth of the reflector are known, the focal point can be found by rearranging **Eqn 5** as follows:

$$A = Y^2/4X \qquad \textbf{(7)}$$

If you already have a dish, the focal point can easily be determined using **Eqn 7**. First measure the reflector diameter with a tape measure. The radius, or Y, is one-half the diameter. If a board or string is placed on the rim from one side of the reflector to the other, the depth, X, can be easily measured. For example, if we have a dish with a depth of 2.5 feet (0.762 meters) and a radius of 10 feet (3.048 meters), the focal point will be 10 feet (3.048 meters).

Next we must determine the f/d or focal length to diameter ratio using the following equation:

$$f/d = A/2Y \qquad \textbf{(8)}$$

Using **Eqn 8**, the f/d ratio in the example above is 0.5 (10/20 feet or 3.05/6.1 meters). We now have all the mathematical parameters necessary to talk intelligently about the design of a parabolic dish type of antenna.

parabolic dish characteristics

So why are the diameter, depth, focal point, and f/d ratio so important? It should be intuitive that the diameter of the reflector is the principal factor that determines the gain of a parabolic antenna. The larger the diameter, the higher the potential gain, as shown on the graph on **fig. 2**.

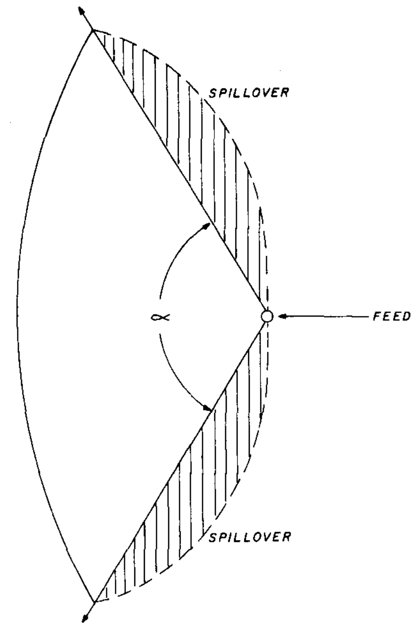


fig. 5. This figure shows how the feed system illuminates the reflector of a parabolic dish. Note that the spillover is the radiation that extends beyond the edge of the dish.

The reflector must follow a parabolic profile (see **eqn. 5**). This curve is calculated after the diameter and f/d ratio of the dish are selected. As dish diameter increases, greater care must be taken to maintain the shape of the reflector.

The depth of the reflector is the parameter that determines the focal length: the deeper the dish, the shorter its focal length. In a "deep" dish, where the f/d ratio is approximately 0.25, the focal point will be on a line parallel to the rim of the dish. The "flatter" the dish, the longer the focal length — and the more difficult it becomes to hold the feed system in place mechanically.

The f/d ratio, however, is probably the most important parameter when designing a parabolic dish antenna from scratch. Let's see why.

In order to use the parabolic dish reflector properly, the feed system must be placed at or near the focal point. Because this feed system "looks" into the dish from the focal point, it must illuminate the subtended

angle between the rims of the dish with a properly tapered radiation pattern as shown in **fig. 5**. (More on this shortly.)

If you have a deep dish with an f/d ratio between 0.25 and 0.4, this subtended angle will be quite large — from 180 to 128 degrees, respectively. If a dish is relatively flat with an f/d ratio between 0.5 and 0.8, the subtended angle will be only 106 to 70 degrees, respectively. For convenience, various subtended angles versus f/d ratios have been plotted in **fig. 6**.

Why is this angle so important? The reasons are many, and all are related to the f/d ratio. Let's first look at some of the tradeoffs.

There are advantages to a low f/d ratio (0.25 to 0.4). This type of dish has a short focal length and hence the support of the feed system is easier from a mechanical standpoint. Generally speaking, the deep dish is quieter on reception. A 0.35 to 0.4 f/d ratio is very common in commercial dishes.

There are also disadvantages to a low f/d ratio. The feed system has to see a wide angle as previously discussed; this makes the feed system more difficult to design. The proximity of the feed to the reflector can cause the feed impedance to change when it's mounted at the focal point. From a mechanical point of view, the deeper the curve, the more difficult is is to fabricate the reflector. There's also greater likelihood that the polarity will become distorted. Usually the low f/d ratio dish demonstrates only moderate efficiency.

A high f/d ratio (0.5 to 0.6) offers several advantages. Because its illumination angle is narrower, the feed system is usually easier to design. The reflector has a flatter profile, making it easier to fabricate. Since the feed point is further from the reflector, it's less likely to be detuned by the reflector. Overall reflector efficiency is generally higher than in a dish with a low f/d ratio.

There are some disadvantages to a high f/d ratio. The feed system, for example, is much further from the reflector and hence more difficult to support. Even if the feed system is properly designed, there will be more spillover and hence more noise pickup than would be expected in a low f/d ratio dish.

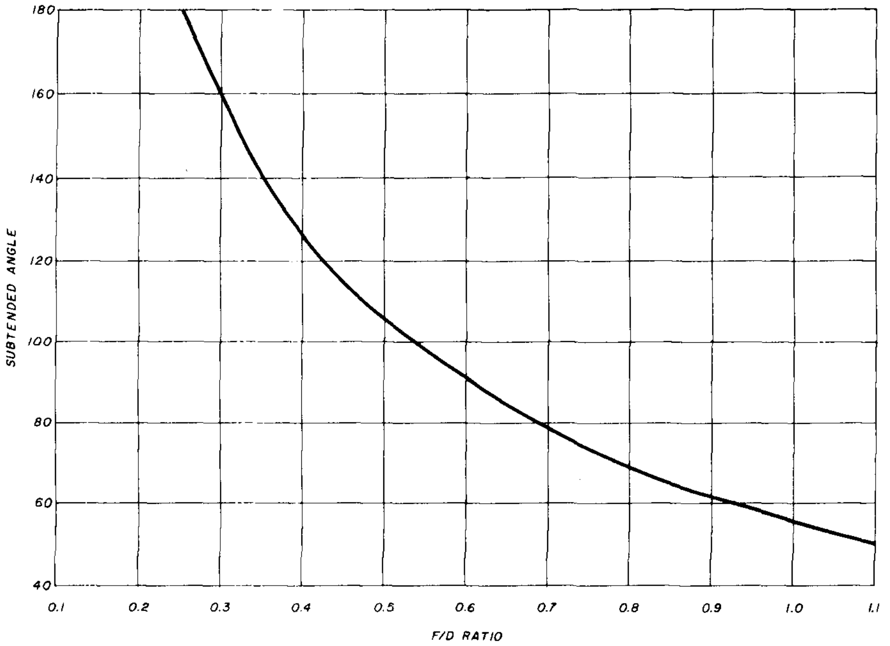


fig. 6. This graph shows the subtended angle (as seen from the feed point) versus the F/D ratio of a parabolic dish reflector.

table 2. Gain and sidelobe levels versus illumination taper on a typical well-designed parabolic dish.

edge illumination in dB	typical level of first sidelobe	approximate overall aperture efficiency (%)
−6	−20.0	68.0
−10	−23.5	81.0
−15	−31.0	77.5
−20	−46.0	69.0

When designing a dish, therefore, the main considerations are the mechanical design and the feed system, which are both governed by the f/d ratio as discussed. From our point of view, as Amateurs, an f/d ratio of 0.45-0.6 seems to be the best compromise since the feed system and the surface of the reflector are easier to design.

feed systems

So far the feed system itself has been mentioned only in passing. Let's look more deeply into the way it has to perform.

As I said earlier, the feed system must illuminate the subtended angle. Furthermore, a parabolic dish is symmetrical in the horizontal as well as the vertical plane, so the feed system must also be symmetrical in both planes.

Although actual feed systems will be discussed in next month's column, their requirements will be spelled out now. It would appear that the feed system should have a half-power beamwidth equal to the illumination angle as shown in **fig. 6**. However, if this were true, a considerable amount of the feed power would be lost

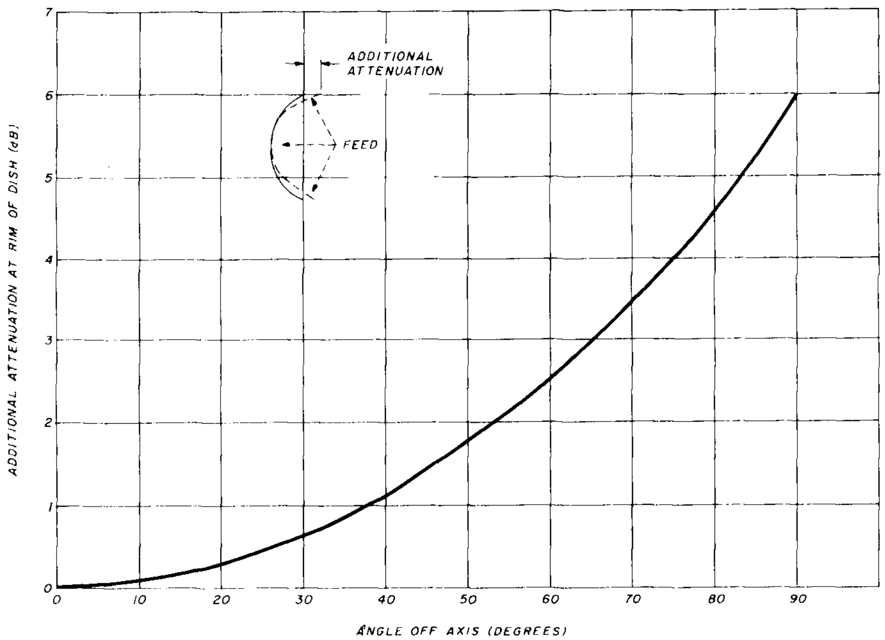


fig. 7. This graph shows the additional "space attenuation" that occurs versus the angle off axis from the feed point on a parabolic dish reflector.

because of "spillover" (see **fig. 5**). Therefore the sidelobes would be high, and in the case of EME, considerable noise would be picked up off the rear of the dish, which is usually the warm earth at 290 degrees Kelvin. On the other hand, if the illuminator feed angle were too narrow, only the center of the reflector would be active and the efficiency of the antenna would decrease — but so would the sidelobes, etc.

Silver[7] and others has discussed this relationship in detail. Most engineers agree that for best overall performance, the optimum feed system should have its −10 dB points right on the rim of the dish. This will yield a reasonably clean pattern and fair gain. The first side lobes will be approximately 23 dB below the main beam. Some typical illumination tapers are shown in **table 2**.

Over-illumination with less than 10 dB feed system taper at the rim of the dish will cause spillover, lower gain, and sidelobes that will be less than 23 dB below the main beam. Conversely, if the dish is under-illuminated and the taper at the rim of the dish is too great, the gain will decrease, as will the side lobes and the noise pickup.

Another factor must be considered: the distance from the reflector to the feed point changes across the reflector. So you can't assume that the feed must be optimum just because the feed system has a −10 dB beamwidth equal to the subtended angle. **Figure 7** shows this amplitude taper as a function of the angle as seen from the feed system. Hence this additional factor has to be taken into consideration when choosing the feed system and the f/d ratio. The lower the f/d ratio is, the greater the "space loss" taper at the edge of the dish will be.

summary

This concludes part 1 of our discussion on the subject of reflector antennas. This month's column has described the relationship between electrical and mechanical considerations in designing a reflector-type antennna and, more specifically, a parabolic dish antenna.

It has also been shown that design tradeoffs are primarily linked to the f/d ratio chosen. Next month's column will deal more with the mechanical design of a reflector and the electrical design of its feed system. Once you have this material in hand, you should be able to design your own parabolic dish antenna and know that it *will* work as planned!

references

1. Joe Reisert, W1JR, "VHF/UHF World: Our Amateur Microwave Bands", *ham radio*, January, 1986, page 44.
2. A. W. Love, *Reflector Antennas*, IEEE Press, 1978.
3. Francis LeBaron, W1TQZ, "A Home-Built Parabolic-Type Reflector for 1296 Mc.," *QST*, April, 1961, page 11.
4. J. D. Kraus, "The Corner Reflector Antenna," *Proceedings of the IRE*, Volume 28, November, 1940, page 513.
5. H. W. Ehrenspeck, "The Backfire Antenna, A New Type of Directional Line Source," *Proceedings of the IEEE*, January, 1960, page 109.
6. H. W. Ehrenspeck, "The Short-Backfire Antenna," *Proceedings of the IEEE*, August, 1965, page 1138.
7. Samuel Silver, *Microwave Antenna Theory and Design*, Massachusetts Institute of Technology Radio Lab No. 12, Boston Technical Publishers, 1964.
8. John D. Kraus, *Antennas*, McGraw-Hill Book Company, 1950.
9. Henry Jasik and Richard C. Johnson, *Antenna Engineering Handbook*, Second Edition, McGraw-Hill Book Company, 1984.
10. Joe Reisert, W1JR, "VHF/UHF World: Stacking Antennas — Part 1," *ham radio*, April, 1985, page 129.
11. Joe Reisert, W1JR, "VHF/UHF World: Determining VHF/UHF Antenna Performance," *ham radio*, May, 1984, page 110.
12. *RF CAD Package — Version 3.50*, Computer-aided design package for radio frequency and microwave circuits and antennas (IBM PC and compatibles), by Joe Reisert, W1JR, and Gary Field, WA1GRC. Available from Ham Radio's Bookstore, Greenville, New Hampshire 03048 $39.95 plus $3.50 shipping and handling.)
13. Don Cook, K1DPP (see callbook) has a free program listing for Commodore 64 computers. Enclose SASE with request.

important VHF/UHF events

February 4: *EME perigee*
March 1: *EME perigee*
March 21: *TE propagation optimum ±2 weeks*
March 28: *EME perigee*

ham radio

improving the audio on the ICOM IC-27

Make an otherwise fine radio even better

The ICOM IC-27 FM transceiver remains, in my opinion, one of the most compact and versatile mobile units available. The performance of my IC-27A was very impressive, with just one noticeable exception: the received audio was poor. Low volume and poor treble response made many noise-free signals all but unintelligible. Many other Amateurs have experienced this problem as well. Fortunately, there's a very simple remedy.

My first inclination was to experiment with an external speaker. The speaker included in the IC-27 is very small. Often such small speakers are inefficient and have poor response. Yet experimentation with a much larger speaker with a more powerful magnet showed absolutely no discernible difference. The only way one could hope to increase the volume would be by mounting an external speaker closer to the user's ear. This would alleviate only part of the problem, however, since the tonal response would remain virtually unchanged. The latter fact was an important clue, because it led me to believe that the audio amplifier inside the IC-27 was the culprit.

strategy

The solution to this problem is simple. Just change one resistor and one capacitor in the audio section. There's absolutely no reason to fear the operation; it's very simple. ICOM has provided excellent schematics with the radio, the board layout is not terribly compact in this area, and all cables running to the important circuit board are provided with well labeled pull-off connectors in an unambiguous configuration. Aside from forgetting to replace a connector, it's virtually impossible to connect anything incorrectly.

As shown in the ICOM schematic, not reproduced here, Q5 and Q6 form an active filter which seems to effectively filter the intelligibility of many Amateurs' speech. Capacitor C67 was found to form the bottleneck; a smaller value is required here. This greatly improves the treble response.

The audio output power was increased by changing the feedback resistor, R31, of the audio power amp, IC6 (on the ICOM schematic). It was discovered that a larger value would give greater gain while still not introducing objectionable distortion.

modification procedure

Begin the modification by turning the transceiver over (speaker side up), and removing the four screws holding the bottom cover. Carefully place the bottom cover to the side (as shown in **fig. 1**) so as not to strain the speaker wires. The connector for the speaker wires can then be pulled at the circuit board.

The objective is to remove the circuit board in order to gain access to the parts which must be changed. Carefully remove connectors J2, J6, J10, and J12. With your fingers, remove the cover plate of the synthesizer section (it's the large shiny box on the right-hand side). Remove the four screws in the corners of the large circuit board. Remove J1 (the entire circuit board at the rear of the unit). Remove the two heat sink screws on IC5 and IC6. Remove the hex spacer formerly under the rear circuit board.

At this point, the entire circuit board can be lifted out. Carefully pull it out and locate the audio section toward the front on the left side, as viewed from the component side. Locate C67. This is a 0.01 μF capacitor near IC6. Using a solder wick or a solder sucker, remove C67 and replace it with a tiny 0.001 μF capacitor. A small ceramic part will do nicely. Then locate R31. This is a 150-ohm, 1/8 watt resistor near J6. Replace this with a 270-ohm resistor. If possible, use a 1/8 watt part so that it will fit easily in the circuit board. Clean your solder connections and carefully check for solder bridges.

This completes the modifications. Replace the circuit board and reverse the disassembly procedure, being careful to replace all removed connectors.

By Edward Richley, KD8KZ, 41 High Point Circle, Naples, Florida 33940

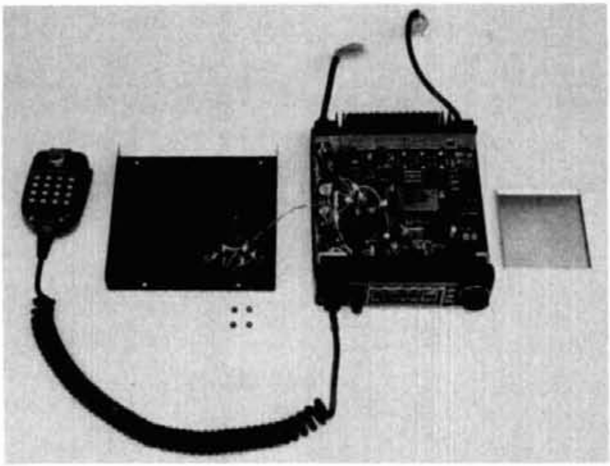


fig. 1. The ICOM IC-27 is easily disassembled for modification.

results

After performing these modifications, I was much happier with the IC-27. Audio volume and clarity are much better than with the original unit, even with the original speaker. In fact, I seriously doubt the need for an external speaker. The internal speaker provides plenty of power,even in my very noisy automobile. I'm sure other Amateurs will agree that this modification makes an otherwise superb radio even better.

ham radio

More Details? CHECK—OFF Page 110

ham radio TECHNIQUES

Bill Orr, W6SAI

what others think of us

When asked about the place of Amateur Radio in today's rapid technological expansion, academician Vladimir Aleksandrovich Kotel'nikov, Vice President of the Academy of Sciences of the USSR and Director of the Institute of Radiotechnology and Electronics of the Academy of Sciences of the USSR, said (in part), "One of the needs of man is the need to create. Amateur Radio opens up broad possibilities in this connection for youths as well as for adults. . . .

"Amateur Radio has been and remains a wonderful school for mass training of personnel for radio electronics. Many young people entered radio electronics via Amateur Radio, judging by our experience. . . .

"The main goal of Amateur creativity has remained unchanged — to attract youth to active participation in the struggle for technical progress and to teach inventiveness, innovation, and improvements in technology. This is very important for our country."[1] (And for ours, too — Ed.)

quad falling apart?

One of the problems with the multi-element quad antenna is keeping it in the air during the months of bad weather. The point at which the loop wire and support structure meet is an area of particular weakness in this design. If fiberglass or bamboo poles are used, the copper antenna wire will "saw" back and forth at this point under the movement of the element in the wind. This sawing motion often results in the breaking of either the support pole or the wire, and the whole antenna must be taken down for repairs.

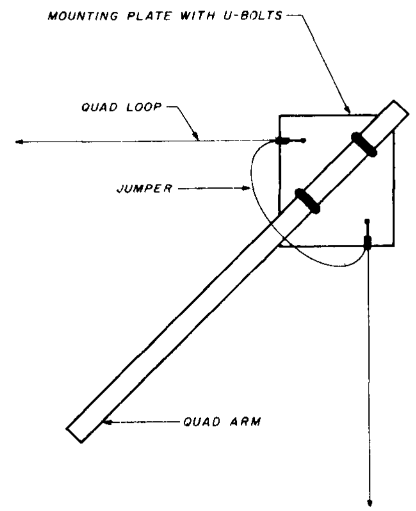


fig. 1. Alternative method of attaching quad loop to quad arm.

Figure 1 shows a novel approach to this problem. An insulating plate (made of fiberglass or formica, for example) is affixed to the quad arm with two U-bolts. The quad wire loop is then attached to holes drilled in the plate and the connection is made as shown in **fig. 1**. Since I don't have a quad up right now, I can't vouch for the idea, but it looks like a good one, and Amateurs planning to erect quads this spring may be interested in trying out this arrangement.

the 160-meter antenna at DJ8WL

DJ8WL, who just returned to Germany after three months in Salt Lake City sent me a sketch of the 160-meter antenna he's using in Germany. Those who've heard his signal can attest to the excellence of the antenna design (**fig. 2**), which he's used since fall, 1984.

His antenna is about 103 feet high (31.4 meters) and is center-loaded by a high-Q coil (L1). A second loading coil is placed at the 19.7 foot (6 meters) level (L2).

Peter uses 50 radials, each 3/8-wave length (205 feet/62.42 meters) long. The feedpoint resistance was measured to be 38 ohms. When only 16 radials were used, the feedpoint resistance was 40 ohms. He estimates his ground resistance to be 9 ohms, so the antenna is about 63 percent efficient.

Antenna response is quite broad, showing less than 1.5:1 SWR over the range of 1800 to 1900 kHz. Peter reports working 9J2JN and LU9EIE the first morning the antenna was on the air!

Peter's antenna was mounted in a tall tree. The top section was made of a fiberglass rod with wire attached, and the lower sections are made of wire. Compared to an inverted-V slung from the same tree at the 80-foot (24.38 meter) elevation, the ground plane produced DX signal reports that were up between 1 to 2 S-units.

DJ8WL's 160-meter DX record with this antenna — as of spring, 1985 — was 135 countries.

aircraft enhancement of VHF/UHF signals

Why does the 2-meter path between San Francisco and Los Angeles pop open every so often, usually in the evening, for just a few minutes? This interesting opening seems to be duplicated in other parts of the world, apparently on a hit-or-miss basis. Doug McArthur (VK3UM) and Ralph Kettle (VK1RK) noticed strange openings on their path, as well as similar openings to VK2ZAB. Path loss was

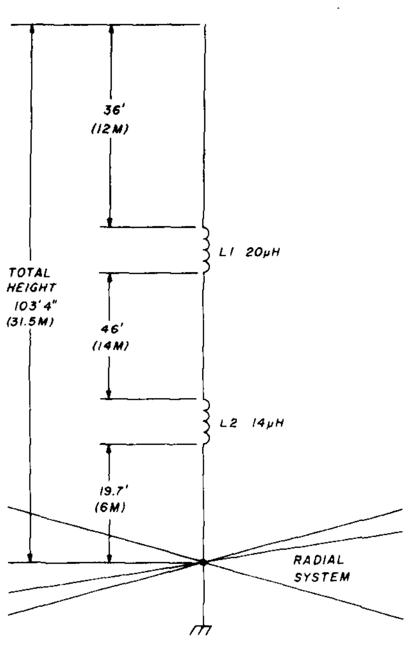


fig. 2. Vertical antenna at DJ8WL has loading coil split in two (L1 + L2). Feed-point resistance is about 40 ohms.

calculated to be −245 dB. The use of medium power, 36-element arrays, and low noise receivers showed that the paths were open for more time than the calculations would indicate. The Melbourne-Canberra path, in particular, had mountainous terrain along the route so direct (i.e., line-of-sight) communication was out of the question, except for occasional tropospheric enhancement. What was causing the strange VHF propagation?

The time of the opening seemed to be related to aircraft passing between the two stations. In particular, two commercial airliners flying from Sydney to Melbourne were midpath at the times of the enhanced propagation.

Upon investigation, it seemed that the height of the flight path and distance of the aircraft from the stations did not tally with the signals received. The signals were too strong and varied markedly with the weather.

VK3UM and his colleagues in the investigation believe that the aircraft are the cause, but not the actual media of the enhanced propagation.

Possible explanations were reflections caused by the condensation trails ("contrails") left by the aircraft flying at about 30,000 feet, or perhaps refraction caused by the air turbulence wake (temperature effect or vortex turbulence).

The size of the aircraft apparently influenced the enhancement, with the highest level obtained from 747s and DC10s. But even aircraft as small as the Fokker F28 provided a good degee of path enhancement. Multiple aircraft, on the other hand, resulted in multipath effects, making copy difficult.[2]

some good news?

It's reported in the technical literature that the new AN/TPS-118 over-the-horizon radar under construction in Maine will soon be on the air. It will provide radar detection of planes at ranges from 500 to 1800 miles (804 to 2897 km). The device uses a transmitting antenna more than 3600 feet long and radiates up to 100 Megawatts of power (effective radiated power) in the 5 to 28 MHz frequency range. Two other sites are planned, one covering the Pacific Coast and one in the Midwest to fill in the skip zones of the other two. That adds up to *three* of these giants grinding away in the continental United States. Let's hope they're programmed to stay out of the ham bands!

a zig-zag dipole antenna

Most compact dipole antennas make use of some form of lumped loading such as an inductor placed in series with the antenna. A few years ago the "zig-zag dipole" was investigated at Hosei University, Tokyo, Japan (**fig. 3**).

One of the more interesting zig-zag dipoles developed and tested used a 0.5 wavelength wire folded back so that the overall length was about 24 percent less than a full-size dipole. The feedpoint resistance was 46 ohms. The included angle was about 130 degrees and each leg of the configuration was as indicated in **fig. 3**.

No mention was made of bandwidth, but it seems to me that the

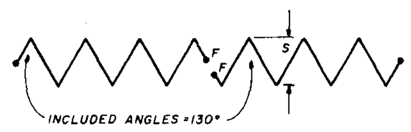


fig. 3. Experimental zig-zag dipole antenna reduces length without use of loading coils.

antenna configuration may provide improved bandwidth because it resembles a "fat" dipole. Some enterprising experimenter should try this antenna on the 80-meter band and see how it performs.

an inexpensive 160-meter antenna that works

No room for a quarter-wave vertical with 120 radials for 160-meter DX work? Too bad. Join me in crying the blues! About the best I can do is a random-length wire running from the house to my nearby antenna tower. I work it against the residence plumbing system as a ground. Recently I added two 8-foot (2.4 meters) ground rods, one at each end of the house, and tied them to the copper water pipe system. So far, so good.

After I'd been working with various end-fed antenna systems for over six months, the back yard was littered with bits of copper wire. I finally ended up with a wire antenna that worked well, although not quite as well as the antennas the "big guns" were using. But if you share my problem of limited space and don't want to grow an antenna farm, this antenna is ideal for you.

Basically, it's a wire about 155 feet (47.24 meters) long. This makes it longer than a quarter-wavelength at 1.8 MHz (130 feet/39.62 meters). The feedpoint impedance of the longer wire is inductive and slightly higher than that of the quarter-wave wire. The inductive reactance is tuned out by a series-connected capacitor and the feedpoint resistance of the antenna (about 23 ohms) is transformed by a shunt inductor to 50 ohms (**fig. 4**).

This design provides an inexpensive matching system to provide a 50 ohm

feedpoint, required by today's modern transceivers. The solid-state amplifiers are not very forgiving with respect to oddball antenna feedpoint impedances, and operation of the 160-meter band stretches the capability of the solid-state amplifier, even under the best conditions.

But this antenna solves that problem. You can change the antenna length and compensate for it with the variable capacitor. As the antenna is shortened toward the quarter wavelength point, the capacitor value increases. As the antenna approaches three-quarter wave resonance, the value of the capacitor diminishes. A happy medium is reached when the antenna is about 0.275 wavelength long. If the inductor and capacitor are variable, the operator can scoot from one end of the band to the other in just a few seconds.

Operational bandwidth of the antenna is quite good; an SWR of better than 1.5:1 can be maintained over 50 kHz without touching the network controls. I tune up at 1825 kHz and am able to QSY up and down 25 kHz at the touch of the transceiver dial.

How well does it work? Well, I'll let you know the results after the next 160-meter DX contest! So far, it seems to be the best wire I've ever had on the "low band."

building the tuner

You can build the tuner on a metal chassis and panel, but it's not necessary (see photo A). My tuner is built on a plywood base with a micarta™ panel. The unit is 8 x 8 inches (25 x 25 x 25 cm). I recommend using a vernier drive on the capacitor because the setting for lowest SWR is quite sharp. The setting of the shunt inductor, on the other hand, is less critical and the counter dial is a luxury. The 3 ampere RF thermocouple meter is very handy for tuneup, so if you can find one at a flea market, buy it and use it. I short mine out with a clip lead after tuneup to keep the meter from jumping around when I'm transmitting.

the 80-40 meter antenna at CN2AQ

Have you heard the strong signal of CN2AQ on 80 meters? He has an antenna that doubles as a telephone line! Look at **fig. 5**. The 328 foot (99.91 meter) wire runs between two buildings. RF chokes at each end of the

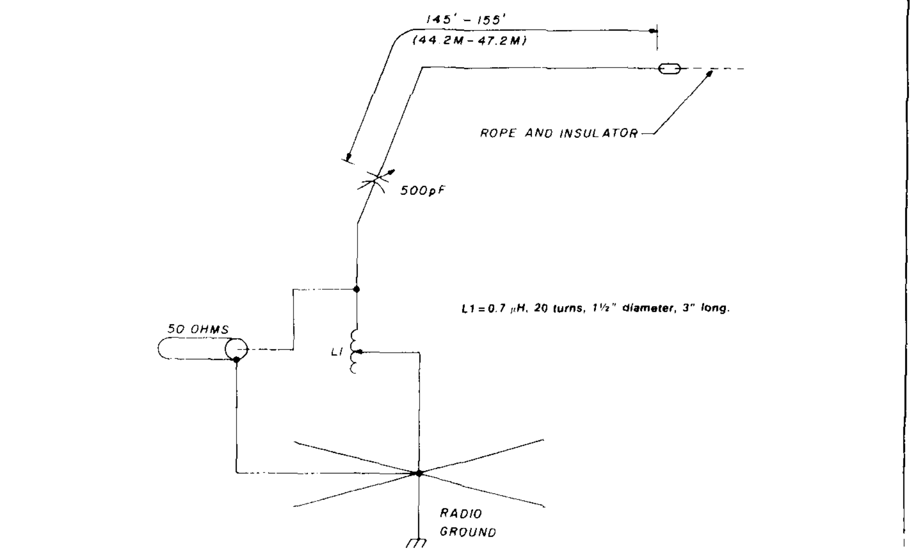


fig. 4. Simple end-fed 160 meter antenna and matching system.

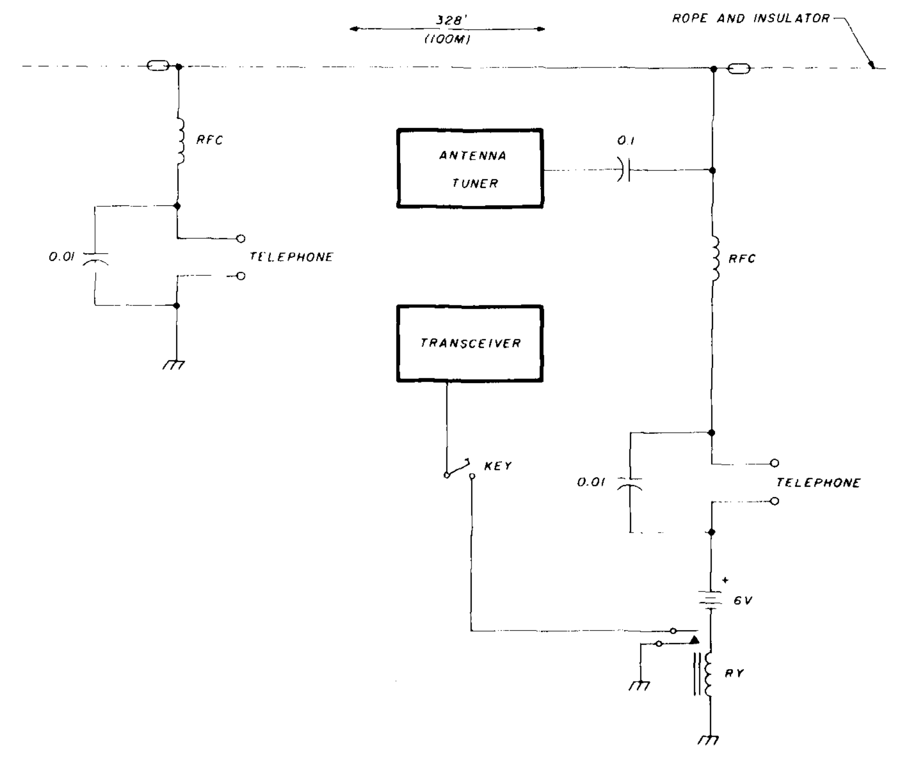


fig. 5. Telephone line and 80-40 meter antenna at CN2AQ. Relay RY opens control circuit of transmitter so it cannot be activated when phone is in use.

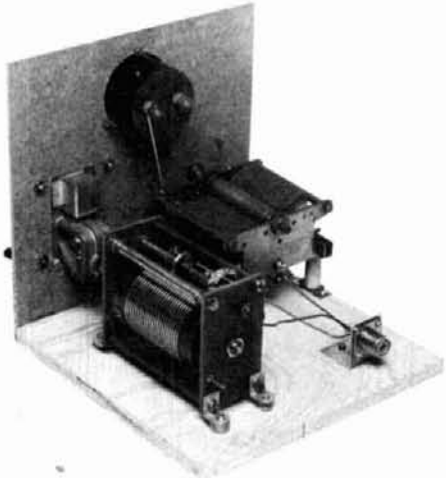


Photo A. W6SAI tuner is built on plywood base.

wire isolate it for the telephone service, in which the return circuit is via ground. In order to prevent the transmitter from being activated when the telephone circuit is in use, a series-connected relay opens the control circuit of the exciter. Now, that seems to be a very practical idea!

what about your antenna?

The sunspot cycle is at low ebb and interest is growing in the 160 and 80-meter bands. I would be interested in hearing about *your* antenna for the low bands. Please send the information to me, care of *ham radio* magazine; the most interesting antennas will be discussed in this column. I hope to hear from you!

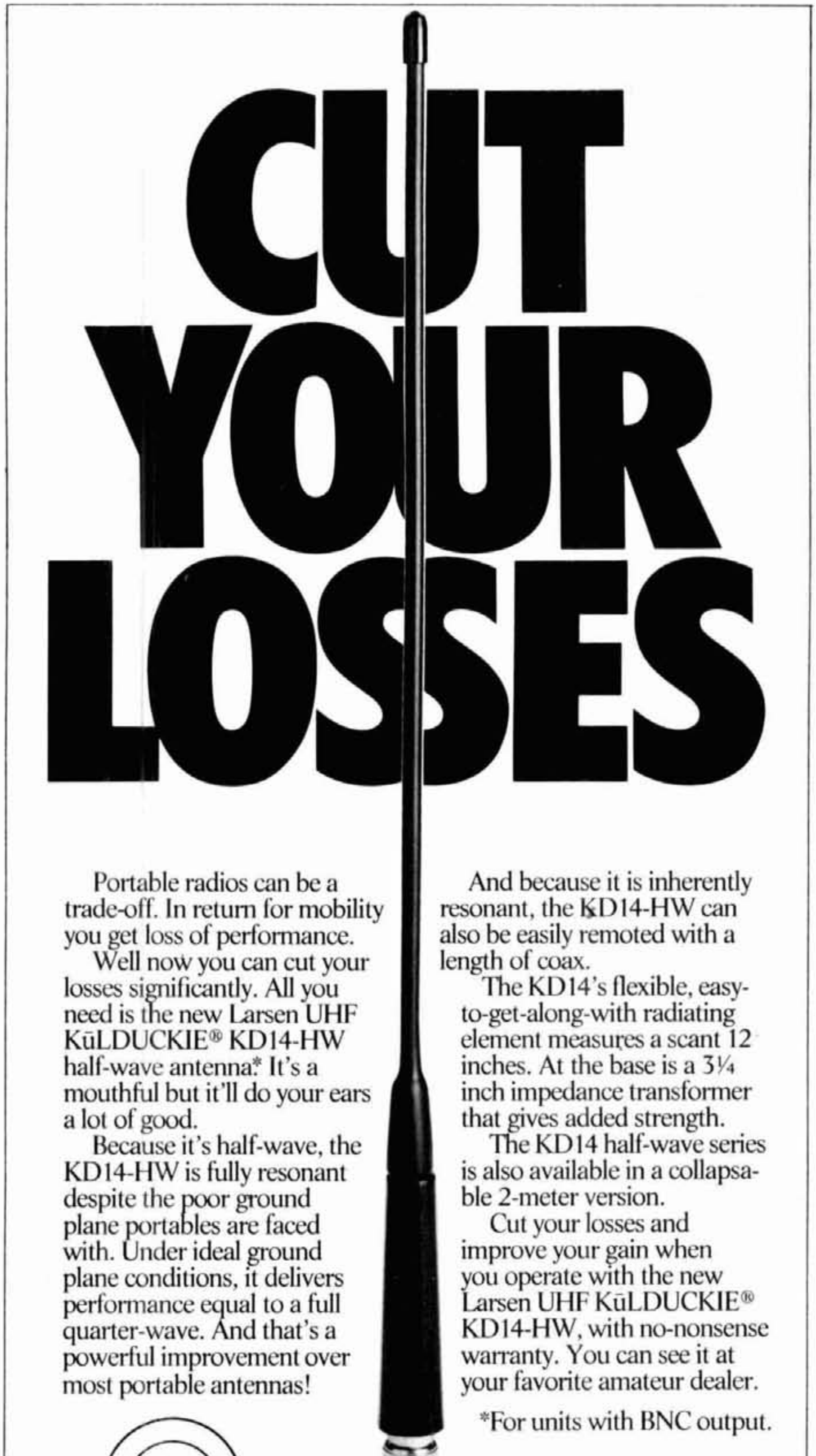
references

1. *Amateur Radio*, Journal of the Wireless Institute of Australia, May, 1985.
2. *Amateur Radio*, Journal of the Wireless Institute of Australia, July, 1985.
3. Nakano, Tagami and Yoshizawa, "Shortening Ratios of Modified Dipole Antennas," *IEEE Transactions on Antennas and Propagation*, Volume AP-32, No. 4, April 1984.

ham radio

Invitation to Authors

ham radio welcomes manuscripts from readers. If you have an idea for an article you'd like to have considered for publication, send for a free copy of the *ham radio* Author's Guide. Address your request to *ham radio*, Greenville, New Hampshire 03048 (SASE appreciated).



141

EME link calculator program

Maximize your station's performance with knowledge of tradeoffs

In trying to set up an EME (moonbounce) station I found it difficult to make trade-offs in terms of antenna gain, coax line losses, preamplifier placement, and output power. What I needed was an easy way to weigh the different parameters against each other. Looking through a few books, I found what I was looking for in the *ARRL Handbook*, the *RSGB VHF-UHF Manual* and in an article by R. Lentz.[1,2,3]

By taking pieces of information from all three sources, I was able to figure out how to vary all the station information in order to calculate the link budget signal-to-noise ratio. However, it became apparent that getting answers by punching buttons on my hand calculator would take a few nights. Also, I was mixing up the answers and station data so much that I couldn't figure out what answer belonged to what station data. Figuring that there had to be a better way, I looked for a computer program to do the job. Not finding one, I wrote the BASIC program included in this article (**fig. 1**). I used Microsoft BASIC for the IBM PC, so it should be able to run as is or with little modification on other PCs or compatibles.

After the requested data is entered, the program provides signal-to-noise ratio (SNR), effective isotropic radiated power (EIRP), and the system noise temperature. Using these figures, you can change the input parameters and see how to best assemble your EME system. With the computer doing most of the work, it's easy to use real numbers, rather than using whatever is convenient, as I did with the calculator.

Both the ARRL and the RSGB handbook examples placed the receive preamplifier at the antenna. They then set the line loss at a convenient zero dB. Since no-loss coax phasing lines don't exist, those example calculations don't really show you what is happening in an antenna array. On the other hand, the program shows that even a 0.5 dB phasing line loss will have a significant effect on the performance at 432 MHz. The computer program provides performance information about an EME station while allowing you to easily change all the station parameters.

realistic data is needed

The data requested by the program is generally familiar. The only data I had trouble figuring out was the sky temperature, which is the actual sky temperature the antenna sees. Don't confuse it with the array temperature, which is sometimes given in antenna articles. Try about 10 to 35 degrees Kelvin for 432 MHz and around 175 to 200 degrees Kelvin for 144 MHz.[4] (Use the lower numbers if your system is in the country and the higher numbers if you live in or near an urban area). At low elevations the antenna will see the earth at 290 degrees Kelvin. This program assumes you're looking high enough with your antenna so that the antenna's main and side lobes clear the earth. After a little practice with the program, you can set the sky temperature higher; this will demonstrate earth effects on EME communications at moon rise or moon set. I left the bandwidth as a variable. Most of the time it should be set at 100 Hz, as the ear and mind can provide that much filter capability. You can set the bandwidth to 1800 Hz to see what kind of signal is required for EME SSB.

The program doesn't provide absolute answers. You can't take an existing station, enter its data into the program, and come out exactly with the way the system works. The real world, after all, includes other factors such as Faraday rotation, noise from you don't know where, and systems built not quite the way they should be. The real benefit of the program is to show the relative merit (or lack of merit) of different ways of putting together an EME station. For instance, what's the benefit of running 1.5 kW instead of 800 Watts? How much better is a 0.3 dB noise figure preamp than a 0.6 dB preamp? Does it make any difference if you use Belden 9913 for phasing lines instead of RG-213/U? Try it and see — you may be surprised.

program structure

The program is divided into six parts: constants, data input, calculations, screen output results, print results and program end. **Lines 10 to 35** contain the program header and set up constant values. **Lines 30 and 35** provide a log to base 10 function as most BASICs have only a log to the base e function. **Lines**

By David Engle, KE6ZE, 1063 Summerwood Court, San Jose, California 95132

```
10     ' Program to calculate signal to noise ratios for EME operations.
11     '       David Engle, KE6ZE        September 1985
12     '
20     K = 1.38E-23 ' Boltzman's constant.
25     TL=290.0 ' Temperature of receive feed line.
30     LOG10E=.434294482 'is log to the base 10 of e.
35     DEF FNLOG10(V)=LOG(V) * LOG10E ' Log to base 10 function
100    ' Get data to set up calculations.
110    PRINT" EME Signal to Noise calculator program" : PRINT
120    INPUT" ENTER FREQUENCY, MHz: ",FREQ
130    INPUT" ENTER TX ANTENNA GAIN, dBi: ",GT
140    INPUT" ENTER TX OUTPUT POWER, WATTS: ",P
150    INPUT" ENTER TX LINE LOSS, dB: ",LT
160    INPUT" ENTER RX ANTENNA GAIN, dBi: ",GR
170    INPUT" ENTER RX LINE LOSS, dB: ",LL
180    INPUT" ENTER RX NOISE FIGURE, dB: ",RN
190    INPUT" ENTER RX BANDWIDTH, Hz: ",B
200    INPUT" ENTER SKY TEMPERATURE, Deg K: ",SKY
210    PRINT
300    'Start calculations.
310    'Transmitter power.
320    PO = 10.0 * FNLOG10(P)
340    'Receiver noise level.
350    TR=((10.0^(RN/10.0)) -1.0 ) * 290.0 'Noise figure to noise temp
360    LR = 10.0^(LL/10.0) ' Noise figure (dB) to noise factor.
370    TS = SKY + ((LR - 1)* TL) + (LR * TR)
380    PN = 10.0 * FNLOG10(K*TS*B)
390    'Path loss.
400    PL = 8.72 * LOG (432/FREQ) - 261
410    'Signal to noise.
420    SNR = PO - LT + GT + PL + GR - PN
430    BAND% = INT (FREQ)
440    EIRP =INT (P*10^((GT-LT)/10.0))
500    'Display the results.
510    PRINT"Transmit EIRP =";EIRP;"Watts,";
520    PRINT" System Noise Temp =";(INT (TS));"Degrees K."
530    PRINT" Signal-to-noise ratio at:"," Perigee,","Mid.,","Apogee."
540    PRINT" for ";BAND%;"MHz band is:", SNR, SNR-1, SNR-2
550    PRINT
600    'Print the results.
610    OPEN "LPT1:" FOR OUTPUT AS #1
620    PRINT#1,
630    PRINT#1,"FREQUENCY =";FREQ;"MHz"
640    PRINT#1,"TX ANTENNA GAIN =";GT;"dBi,";
650    PRINT#1," TX OUTPUT POWER =";P;"Watts,";
660    PRINT#1," TX LINE LOSS =";LT;"dB"
670    PRINT#1,"RX ANTENNA GAIN =";GR;"dBi,";
680    PRINT#1," RX LINE LOSS =";LL;"dB"
690    PRINT#1,"RX NOISE FIGURE =";RN;"dB,";
700    PRINT#1," RX BANDWIDTH =";B;"Hz"
710    PRINT#1,"SKY TEMPERATURE =";SKY;"Deg K"
720    PRINT#1,
730    PRINT#1,"Transmit EIRP =";EIRP;"Watts,";
740    PRINT#1," System Noise Temp =";(INT (TS));"Degrees K."
750    PRINT#1,"Signal-to-noise ratio at:"," Perigee,","Mid.,","Apogee."
760    PRINT#1," for ";BAND%;"MHz band is:", SNR, SNR-1, SNR-2
770    PRINT#1,
780    CLOSE #1
900    INPUT" Do you wish to continue? (Y/N) ",ANS$
910    IF ANS$="Y" OR ANS$="y" THEN 120
```

fig. 1. EME station optimization program listing.

Frequency = 144 MHz
TX Antenna Gain = 21 dBi, TX Output Power = 1500 Watts, TX Line Loss = 0.5 dB

RX Antenna Gain = 21 dBi, RX Line Loss = 0.5 dB

RX Noise Figure = 0.5 dB, RX Bandwidth = 100 Hz

Sky Temperature = 170 Deg K

Transmit EIRP = 168302 Watts, System Noise Temp = 245 Degrees K.

Signal-to-noise ratio at:	Perigee,	Mid.,	Apogee
for 144 MHz band is:	6.548783	5.548783	4.548783

fig. 2A. Typical data displayed in run of SNR program.

PO = 31.760
TR = 35.385
LR = 1.122
TS = 245.088
PN = −184.708
PL = −251.420
SNR = 6.548

fig. 2B. Intermediate values generated for fig. 1 results.

100 to 210 inquire and retrieve the station data from the operator (you). **Lines 300 to 440** do the calculations and come up with the answers. **Line 350,** which converts the preamplifier gain in dB to noise temperature, is from the RSGB manual. **Line 360** converts the receiver (preamplifier) line loss into a ratio.[3] **Line 400** provides the path loss. (The path loss is an approximation — a little high at 50 MHz, right on at 432 MHz, and a little low at 2304 MHz. All are within 1 dB.) **Lines 500 to 550** display the answers on your screen. **Lines 600 to 780** print both the input data and the answers on your line printer. If you have no printer, omit **lines 600 to 780. Line 610** sets the printer up. If your computer calls its printer something other than "LPT1," you'll have to change this line accordingly. **Lines 900 to 999** re-run or end the program.

sample run checks program

Figure 2A contains a set of data to run through the program after you get it entered in the computer. This can be used to check the accuracy of what you've typed in. If you don't get the answers listed to within 0.1 dB, exit the program by answering "N" to the question, "Do you wish to continue?" You should still be running BASIC at this point, so you can look at the intermediate answers from the program. Simply type "PRINT PO," "PRINT PL," and those values will be printed on the screen. Any of the intermediate values used in the program (e.g., PO, TR, LR, TS, PN, PL, SNR) may be looked at in this manner. **Figure 2B** contains the set of intermediate values generated during the **fig. 2A** example. If your answers are different from these examples, then you have an error in one of the previous lines that works on that variable.

I hope this program can help you demystify the optimization of your EME station. A couple of the more interesting things I noticed were the effects of phasing line loss and preamplifier noise figure on the system's performance. These effects are easily noticed in the system noise figure. Fire it up and plug in your numbers. It may be easier to improve your system than you think!

references

1. Charles Hutchinson, K8CH, Editor, *The ARRL 1985 Handbook for the Radio Amateur*, American Radio Relay League, Newington, Connecticut, 62nd Edition, Chapter 23, pages 11 and 12.
2. D.S. Evans, G3RPE, and G.R. Jessop, G6JP, Editors, *VHF-UHF Manual*, Radio Society of Great Britain, London, 3rd Edition, Chapter 9, pages 12 to 14.
3. R. Lentz, DL3WR, "Noise in Receive Systems," *VHF Communications*, 4/1975, pages 217 to 235.
4. Steve Powlishen, K1FO, "Stacking Yagis Is A Science," *ham radio*, May, 1985, pages 18 to 23.

ham radio

ham radio Reader Service

For literature or more information, locate the Reader Service number at the bottom of the ad, circle the appropriate number on this card, affix postage and send to us. We'll hustle your name and address to the companies you're interested in.

101	113	125	137	149	161	173	185	197	209	221	233	245	257	269	281	293	305	317	329	341
102	114	126	138	150	162	174	186	198	210	222	234	246	258	270	282	294	306	318	330	342
103	115	127	139	151	163	175	187	199	211	223	235	247	259	271	283	295	307	319	331	343
104	116	128	140	152	164	176	188	200	212	224	236	248	260	272	284	296	308	320	332	344
105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285	297	309	321	333	345
106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286	298	310	322	334	346
107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313	325	337	349
110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315	327	339	
112	124	136	148	160	172	184	196	208	220	232	244	256	268	280	292	304	316	328	340	

Limit 15 inquiries per request.

NAME ______________________________ CALL ____________

ADDRESS ______________________________________

CITY ____________________ STATE __________ ZIP __________

Please use before March 31, 1986

February 1986

AFFIX POSTAGE
OR
POST OFFICE
WILL NOT
DELIVER

ham
radio
magazine

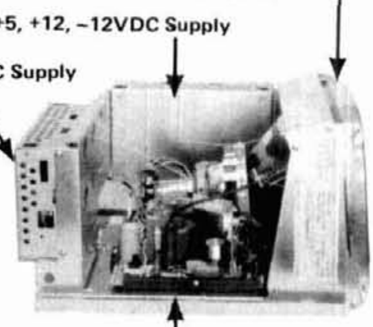
READER SERVICE CENTER
P.O. BOX 2558
WOBURN, MA 01888

ATTN: Reader Service Dept.

John J. Meshna Jr., Inc.

P. O. Box 62 19 Allerton St. E. Lynn, Ma. 01904 Tel: (617) 595-2275

COMPUTER TERMINAL BUILDING BLOCK $50.00



This is a great beginning for a computer terminal. It is a brand new, Panasonic, 9" TTL input monitor complete with its own self-contained, switching power supply, and a removeable (four screws) triple output power supply. The whole assembly runs on 115/230 V, 50/60 Hz. Now for some specifics: 9" green phosphor, TTL input monitor, attached regulated 12 VDC, 1.5 A power supply used exclusively to run the monitor and an attached triple output switching power supply with outputs of 5 VDC @ 3.5 A, +12 VDC @ 500 ma, and −12 VDC @ 500 ma. The assembly has mounting feet and should be a snap to make a case for. Comes with hook up data. New, factory boxed. We are offering this to you 4 ways:

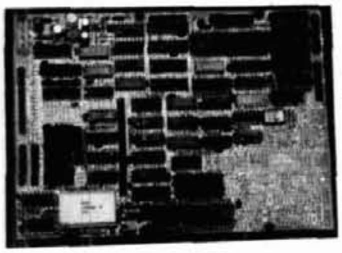
- COMPLETE SET-UP AS SHOWN, including monitor, low voltage supply and triple output supply. SPL-116-38, 14 Lbs., $50.00, 5/$225.00
- TRIPLE OUTPUT SUPPLY ONLY, SPL-117-38, 3 Lbs. $15.00
- 9" MONITOR ONLY, (you supply low voltage input) SPL-114-38, 10 Lbs. $ 25.00
- 9" MONITOR W/LOW VOLTAGE SUPPLY ONLY, SPL-115-38, 12 Lbs. $40.00

ATTENTION:
SECURITY PERSONNEL
NATURALISTS
HOBBYISTS
NEW SEE-IN-THE-DARK EQUIPMENT!

We are now selling guaranteed working, starlight scopes which allow sight in almost total darkness. They are so named because they incorporate a light amplification tube which uses the available star or moon light to allow you to see - without being seen. The scope has a spectral response of **4,500 to 8,000 angstroms,** resolution of 50 lines/mm, viewing area of 25mm, standard 50mm F1.4 lens, optional telephoto 135mm F2.8 lens, cross hair reticle and optional carrying case. A great tool for security and naturalist applications. Runs on 9VDC transistor radio battery. Due to the nature of this device and people only having a one time use for it, we cannot accept returns for refund, credit or exchange on this item. To our knowledge, this is the least expensive starlight scope on the market. Includes 90 day warranty.

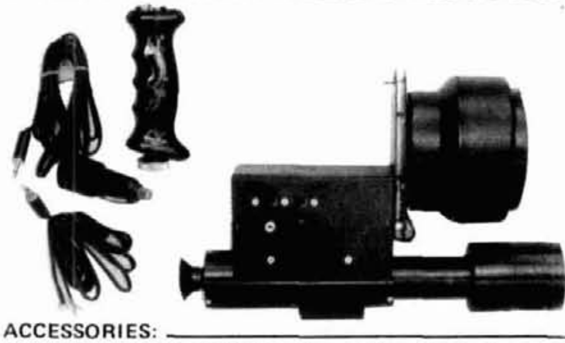
STARLIGHT SCOPE	**SPL-130A-39**	**$1,200.00**
Optional Telephoto Lens, 135mm F2.8	**SPL-131A-39**	**$85.00**
Optional Fitted Carrying Case	**SPL-132A-39**	**$65.00**

5 ¼" HARD DRIVE CONTROLLER CARD



Finally, affordable, intelligent disc drive controllers are available at low, low surplus prices. The OMTI 20C controller boards we offer are unused, late style, surplus from a now defunct system house. OMTI is a division of Scientific Micro Systems. These boards will handle up to (2) 5¼ inch Winchester type hard drives that utilize a standard 34 pin SASI interface. Perfect for using with the above Seagate ST 506 drive, or other hard drives from 5 megabytes of storage on up. The controllers have buffered slew/seek modes, overlapped seeks, auto seek & verify, extensive fault detection, auto head & cylinder switching, full sector buffering, 256/512 bytes/sector, 33 or 18 sectors/track (jumper selectable), programmable disc parameters and much more. The board runs on +5 vdc & +12 vdc.. We supply users manual & pinout data. Guaranteed O. K.. Shpg. wt. 3 lb. OMTI 20 C $150.00 each 2/$275.00 Qty. pricing available.

HIGH POWER SURVEILLANCE IR SCOPE



This Infra-Red scope was designed specifically for long range surveillance use. The built-in, totally invisible, 50 watt halogen lamp IR source is coupled with a premium grade type 6032 image converter tube, 265 mm f4.2 lens, and 16 power military spec., color corrected eyepiece make this an ideal unit for viewing of clandestine activities or animals. The scope is capable of detection at more than 300 feet, recognition at 300 feet and positive facial identification at 150 feet. It runs on 12 VDC which makes it ideal for mobile use. It comes with a removeable hand grip which allows for tripod mounting, 2 power cords for cigarette lighter or battery terminals, instructions and a 90 day warranty. *Listed below are accessories which make this a very* versatile instrument. The scope and accessories are new and guaranteed functional. Net wt. 5-1/4 Lbs.

IR Scope part no. ELD Shpg. Wt. 7 Lbs. $735.00 ea.

ACCESSORIES:

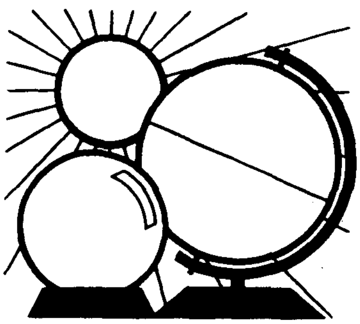
12 VDC GELL BATTERY for above. Shpg. Wt. 6 Lbs. $35.00

BIOCULAR EYEPIECE which can be used in place of the standard eyepiece. This allows the scene being produced by the IR viewer to be seen by the operator up to 4 ft. away. 2 Lbs. $89.95

MALE "T" f1.6 CAMERA DAPTER for SLR cameras Shpg. Wt. 1 Lb. $129.00

MALE "C" to FEMALE "T" ADAPTER for CCTV, requires use of above male "T" f1.6 adapter. Shpg. Wt. 1 Lb. $29.95

Free 72 page catalogue available or send $1.00 for 1st class service to P. O. Box 62 E. Lynn, Ma. 01904. **Phone (617) 595-2275 to place your order by phone. MC, VISA, or American Express charge cards accepted.**



DX FORECASTER

Garth Stonehocker, KØRYW

sunspots and MUFs

Because we're nearing the 11-year sunspot number minimum, the Institute for Telecommunication Science study comparing MUF distribution of values for low, medium, and high sunspot numbers should be of interest. **Table 1** (similar to last month's) lists *the ratios of the 10- and 90-percentile* monthly median MUF values. The data is separated into day and night groups over three solar activity ranges: low (68-88) sunspots in the years 1954-55; medium (90-115) in the years 1961-62; and high (200-285) in the years 1957-58 at various control point latitudes. The upper decile values (90 percent) use the column head + % and the lower decile (10 percent) by − % in the table. A separate listing is provided for daytime and nighttime periods.

Notice that greater deviations from median occur in the high (70 degree) and low (10 degree) latitudes in all sunspot categories regardless of whether it's local daytime or nighttime. However, the largest deviations occur during a high sunspot number year and at night. This increased MUF is from the solar flare particles arriving via the solar wind at the polar ionosphere down the open geomagnetic field lines from the sun (see the geomagnetic field drawing in "DX Forecaster," June, 1985, page 102) on the day side of the earth. On the night side the particles come into the ionosphere from the stored particle areas (Van Allen belts) along the closed and tail geomagnetic field lines.

The exception to the foregoing pattern is the *20-degree latitude night* values at low and medium sunspot numbers. Here the geomagnetic variations help the ions drift upward along the closed field lines until within 20 degrees of the geomagnetic equator. This is a winter nighttime effect during medium to low sunspot numbers. Here again is evidence of trans-equatorial DX propagation; it is *accompanied by an F-region trough* (with low MUFs) just south of the auroral zone. The low MUFs in the trough are shown by the large − % numbers at 70 degrees latitude during the night. The increased geomagnetic variability during low to medium sunspot numbers results from a stronger solar wind stream through a thinning solar corona while the sun is yet somewhat active. *This data, the MUF distribution statistical trends of propagation effects, can be used to understand and improve DX operating skills.*

last minute forecast

The best DX conditions for the higher frequency bands are expected during the first and last weeks of February. The solar flux base level should increase about 5 units in January and February. So look for some increase in MUFs in the midlatitudes as last month's table showed. Trans-equatorial propagation should be good and enhanced by some geomagnetic disturbances around the 10th and 24th of the month. The lower frequency bands are expected to be very good

table 1. Variation in the ratio of monthly median MUF values.

Latitude	Sunspot Range	− % Day	+ %	− % Night	+ %
70	Low	22	23	28	29
	Medium	24	29	23	30
	High	26	29	27	30
50	Low	19	15	21	21
	Medium	21	17	21	21
	High	22	22	21	18
30	Low	17	17	22	26
	Medium	19	17	24	25
	High	14	17	18	18
20	Low	21	19	26	31
	Medium	18	19	27	34
	High	12	14	21	26
10	Low	14	18	26	27
	Medium	15	17	25	27
	High	12	15	20	25

FEBRUARY

WESTERN USA

GMT		2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000
PST		3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00
ASIA FAR EAST	N	_40_	_40_	_40_	_40_	40	40	40	40	40	_40_	_40_	_40_	_40_	_40_	_40_	40	40	40	40	30	30	20	20	30*
EUROPE	NE	40	40	40*	30	20	20	20	20	20	20	30	_40_	_40_	_40_	_40_	_40_	_40_	_40_	_40_	40	40	40	40	40
S. AFRICA	E	15	15	12	12*	10	10	10	10	10	12	15	_30_	_30_	_30_	_30_	_30_	_30_	_30_	30	20	20	20	20	20
S. AMERICA	SE	10	10	10	10	10	10	10	10	12*	15	_20_	_30_	_30_	_20_	_20_	_20_	20	20	20	20*	15	12	10	10
ANTARCTICA	S	12	12	12	12	12	12	12	15	20	_30_	_30_	_30_	_20_	_20_	_20_	20	20	20*	15	12	12	12	12	12
NEW ZEALAND	SW	10	10	12	12	15	20*	20	20	20	_30_	_30_	_20_	_20_	_20_	_20_	_20_	20	20	15	15	10	10	10	10
OCEANIA AUSTRALIA	W	12	12	15	15	20	20	20	20	20	_30_	_30_	_30_	_20_	_20_	_20_	20	20	20	20	15	12	10	10	10
JAPAN	NW	20*	20	20	20	_40_	_40_	_40_	_40_	_40_	_40_	_40_	_40_	40	40	40	40	40	40	30	30	20	20	20	20*

MID USA

MST		4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00
ASIA FAR EAST	N	_40_	_40_	_40_	_40_	40	40	40	40	40	_40_	_40_	_40_	_40_	_40_	_40_	40	40	40	40	40	30	30	30	40
EUROPE	NE	40	40	40*	30	20	20	20	20	20	20	20	20	30	_40_	_40_	_40_	_40_	_40_	_40_	40	40	40	40	40
S. AFRICA	E	15	15	12	12*	10	10	10	10	10	10	12	15	_30_	_30_	_30_	_30_	_30_	_30_	30	20	20	20	20	20
S. AMERICA	SE	10	10	10	10	10	10	10	10	12*	15	20	_30_	_30_	_20_	_20_	_20_	_20_	20	20	20	15	15	12	10
ANTARCTICA	S	12	12	12	12	12	12	12	15	15	20*	20	_30_	_30_	_30_	_20_	_20_	_20_	20	20	20*	15	12	12	12
NEW ZEALAND	SW	10	10	12	12	15	15	20	20	20	20	_30_	_30_	_30_	_30_	_20_	_20_	20	20	20	15	15	12	10	10
OCEANIA AUSTRALIA	W	10	12	12	15	20	20	20	20	20	20	_30_	_30_	_30_	_30_	_30_	_20_	_20_	20	20	20	20	15	12	10
JAPAN	NW	20	20	20	30	_40_	_40_	_40_	_40_	_40_	_40_	_40_	_40_	_40_	40	40	40	40	40	40	30	30	30	20	20
CST		5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00

EASTERN USA

EST		6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00
ASIA FAR EAST	N	_40_	_40_	_40_	_40_	40	40	40	40	40	_40_	_40_	_40_	_40_	_40_	_40_	40	40	40	40	40	40	40	40*	40
EUROPE	NE	40	40	30	30	20	20	20	20	20	20	20	20	20	30	_40_	_40_	_40_	_40_	_40_	40	40	40	40	40
S. AFRICA	E	20	15	12	12*	10	10	10	10	10	10	10	10	12	15	_30_	_30_	_30_	_30_	30	20	20	20	20	20
CARIBBEAN S. AMERICA	SE	10	10	10	10	10	10	10	10	10	12	12	15	20	_30*_	_20_	_20_	_20_	_20_	20	20	20	15	15	12
ANTARCTICA	S	12	12	12	12	12	12	12	12	15	15	15	20	_30_	_30_	_30_	_20_	_20_	_20_	20	20	20*	15	12	12
NEW ZEALAND	SW	10	10	12	12	15	15	20	20	20	20	20	_30_	_30_	_30_	_30_	_30_	_30_	20	20	20	20	20	15	12
OCEANIA AUSTRALIA	W	12	12	12	15	20	20	20	20	20	20	_20*_	_30_	_30_	_30_	_30_	_30_	_30_	_20_	20	20	20	20	15	12
JAPAN	NW	20	20	20	30	_40_	_40_	_40_	_40_	_40_	40	40	40	_40_	_40_	_40_	_40_	_40_	40	40	40	40	40	30	30

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next **higher** band for possible openings.

throughout the month, but especially good around mid-month.

No significant meteor showers occur during February. The full moon is on the 2nd and lunar perigee is on the 4th.

band-by-band summary.

Ten, twelve, fifteen, and twenty meters will be open from morning to early evening almost every day, and to most areas of the world. The openings on the higher of these bands will be shorter — to the southern hemisphere — and will occur closer to local noon. Transequatorial propagation on these bands will more likely occur toward evening during conditions of highest solar flux and a disturbed geomagnetic field.

Thirty and forty meters will be useful almost 24 hours a day. Daytime conditions will resemble those on 20 meters, except that skip distances and signal strength may decrease during midday on days that coincide with the higher solar flux values. Nighttime DX will be good except after days of high MUF conditions and during geomagnetic disturbances. Look for DX from unusual places on east, north, and west paths during daytime and southern paths at night. The usable distance is expected to be somewhat less than 20 in daytime and greater than on 80 at night.

Eighty and one-sixty meters will exhibit short-skip propagation during daylight hours and lengthen for DX at dusk. These bands follow the darkness regions opening to the east just before your sunset, swinging more to the north-south near midnight and ending up in the Pacific areas during the hour or so before dawn on the path of your interest. The 160-meter band opens later and ends earlier than the 80-meter band.

ham radio

THE STANDARDS OF EXCELLENCE

SUPERIOR WEAK SIGNAL PERFORMANCE COMMERCIAL MODEM

COMPARE with *ANY* unit at *ANY* Price

Now Available With PACKET RADIO

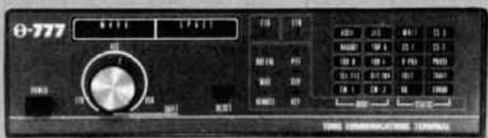
THE WORLD OF VHF/HF PACKET*, CW, RTTY, ASCII AND NEW DUAL AMTOR IS AS CLOSE AS YOUR FINGERTIPS WITH THE BRILLIANTLY INNOVATIVE STATE-OF-THE-ART MICRO-COMPUTER CONTROLLED EXL-5000E.**

SPECIAL SALE
$649
With Packet Radio — $795

SHOWN WITH OPTIONAL PACKET TNC

Everything built in — nothing else to buy!

• AUTOMATIC SEND/RECEIVE—*ANY* SPEED *ANY* SHIFT • BUILT IN COMPUTER GRADE 5" MONITOR • EXTERNAL MONITOR JACK • TIME CLOCK ON SCREEN • TIMED TRANSMISSION AND RECEIVING • SELCAL • CRYSTAL CONTROLLED AFSK MODULATOR • PHOTOCOUPLER CW, FSK KEYER • ASCII KEY ARRANGEMENT • 15 CHANNEL BATTERY BACK-UP MEMORY • 1,280 CHARACTER DISPLAY MEMORY • SPLIT SCREEN TYPE-AHEAD BUFFER • FUNCTION SCREEN DISPLAY • PARALLEL PRINTER INTERFACE • SPEEDS: CW 5-100 WPM (AUTOTRACK), 12-300 BAUD (ASCII AND BAUDOT); 12-600 BAUD TTL; 100 BAUD ARQ/FEC AMTOR • ATC • RUB-OUT FUNCTION • AUTOMATIC CR/LF • WORD MODE • LINE MODE • WORD WRAP AROUND • ECHO • TEXT CURSOR CONTROL • USOS • DIDDLE • TEST MESSAGES (RY AND QBF) • MARK AND BREAK (SPACE AND BREAK) SYSTEM • VARIABLE CW WEIGHTS • AUDIO MONITOR CRICUIT BUILT IN • CW PRACTICE FUNCTION • CW RANDOM GENERATOR • BARGRAPH LED METER FOR TUNING • OSCILLOSCOPE OUTPUTS • BUILT IN 100-120 / 220-240 VAC 50/60HZ AND 13.8VDC POWER SUPPLIES • AND MUCH, MUCH MORE • SIZE: 14W x 14D x 5H • 1 YEAR LIMITED WARRANTY •



SPECIAL SALE $249

Θ-777 THE MOST ADVANCED COMPUTER INTERFACE EVER DESIGNED FOR COMMERCIAL AND AMATEUR USE.

RTTY, BIT INVERSION (RTTY), ASCII, AMTOR (MODE A (ARQ), MODE B (FEC AND SEL-FEC), MODE L), CW, *ANY* SPEED *ANY* SHIFT (ASCII AND BAUDOT)*

- **AUTO DECODING: Automatically decodes signal and displays mode, speed and polarity on the CRT — COMPARE!**
- **28 BAR-LED'S and LED'S plus a Bar-Graph Tuning Indicator indicate function, mode, and status — COMPARE!**
- **The awesome power of the Θ-777 is limited only by the imagination of the user and the terminal program of the computer.**
- **Use with *Any* computer that has RS232 or TTL I/O, IBM, Apple, Commodore, TRS80, etc.**

Everything Built In - Including Software — Nothing Else To Buy!

• *SPEEDS: CW 5-100 WPM (AUTOTRACK), 12-200 BAUD (ASCII AND BAUDOT); 12-600 BAUD TTL, AND RS232 OR TTL LEVEL DATA CONNECTION - 100-2400 BAUD (ASCII) OR 45.5-200 BAUD (BAUDOT) • SELCAL • MEMORY: 15 CHANNELS +768 CHARACTER INPUT BUFFER • AUTO PTT • CW ID • DIDDLE • USOS • ECHO • AUTO CR/LF • ATC • RUB-OUT • CW PRACTICE GENERATOR • VARIABLE CW WEIGHTS • TEST MESSAGE (RY AND QBF) • FULL CRT FUNCTION DISPLAY • MARK - AND - BREAK (SPACE - AND -BREAK) SYSTEM • XTAL AFSK • AUDIO MONITOR • OSCILLOSCOPE OUTPUTS • AND MUCH, MUCH MORE • POWER SUPPLY REQUIREMENTS: 13.8 V DC, 700MA • SIZE: 9W x 10D x 2½H • 1 YEAR LIMITED WARRANTY •

EXCLUSIVE DISTRIBUTOR: DEALER INQUIRIES INVITED — FOR YOUR NEAREST DEALER OR TO ORDER:

AMATEUR-WHOLESALE ELECTRONICS — **TOLL FREE...800-327-3102**

8817 S.W. 129th Terrace, Miami, Florida 33176 — Telephone (305) 233-3631 — Telex: 80-3356

MasterCard

VISA

MANUFACTURER:

TONO CORPORATION

98 Motosoja Machi, Maebashi-Shi, 371, Japan

*PLEASE CALL FOR DETAILS

**Dual Amtor: Commercial quality, the EXL-5000E incorporates *two completely separate modems* to fully support the amateur Amtor codes and *all* of the CCIR recommendations 476-2 for commercial requirements.

Specifications Subject to Change.

ICOM

HF Equipment	Regular	SALE
IC-735 HF transceiver/SW rcvr/mic	849.00	729^{95}
PS-55 External power supply	160.00	144^{95}
AT-150 Automatic antenna tuner	349.00	314^{95}
FL-32 500 Hz CW filter	59.50	
EX-243 Electronic keyer unit	50.00	
IC-745 9-band xcvr w/.1-30 MHz rcvr	999.00	769^{95}
PS-35 Internal power supply	160.00	144^{95}
EX-241 Marker unit	20.00	
EX-242 FM unit	39.00	
EX-243 Electronic keyer unit	50.00	
FL-45 500 Hz CW filter (1st IF)	59.50	
FL-54 270 Hz CW filter (1st IF)	47.50	
FL-52A 500 Hz CW filter (2nd IF)	96.50	89^{95}
FL-53A 250 Hz CW filter (2nd IF)	96.50	89^{95}
FL-44A SSB filter (2nd IF)	159.00	144^{95}
HM-10 Scanning mobile microphone	39.50	
SM-6 Desk microphone	39.00	
HM-12 Extra hand microphone	39.50	
MB-12 Mobile mount	19.50	

IC-751 9-band xcvr/.1-30 MHz rcvr	1399.00	1089
PS-35 Internal power supply	160.00	144^{95}
FL-32 500 Hz CW filter (1st IF)	59.50	
FL-63 250 Hz CW filter (1st IF)	48.50	
FL-52A 500 Hz CW filter (2nd IF)	96.50	89^{95}
FL-53A 250 Hz CW filter (2nd IF)	96.50	89^{95}
FL-33 AM filter	31.50	
FL-70 2.8 kHz wide SSB filter	46.50	
HM-12 Extra hand microphone	39.50	
SM-6 Desk microphone	39.00	
RC-10 External frequency controller	35.00	
MB-18 Mobile mount	19.50	

IC-720A 9-band xcvr • **(CLOSEOUT)** •	1349.00	699^{95}
PS-15 20A external power supply	149.00	134^{95}
FL-32 500 Hz CW filter	59.50	
FL-34 5.2 kHz AM filter	49.50	
BC-10A Memory back-up	8.50	
SM-5 8-pin electret desk mic	39.00	
MB-5 Mobile mount	19.50	

Other Accessories:	Regular	SALE
PS-15 20A external power supply	149.00	134^{95}
CF-1 Cooling fan for PS-15	45.00	
EX-144 Adaptor for CF-1/PS-15	6.50	
PS-30 Systems p/s w/cord, 6-pin plug	259.95	234^{95}
OPC Opt. cord, specify 2, 4 or 6-pin	5.50	
SP-3 External base station speaker	49.50	
SP-5 Remote speaker for mobiles	25.00	
CR-64 High stab ref. xtal (745/751)	56.00	
PP-1 Speaker/patch (specify radio)	139.00	129^{95}
SM-8 Desk mic - two cables, Scan	69.95	
AT-100 100W 8-band auto. antenna tuner	349.00	314^{95}
AT-500 500W 9-band auto. antenna tuner	449.00	399^{95}
AH-1 5-band mobile antenna w/tuner	289.00	259^{95}
GC-4 World clock • **(CLOSEOUT)** •	99.95	79^{95}

HF linear amplifier	Regular	SALE
IC-2KL 160-15m solid state amp w/ps	1795.00	1299

6-meter VHF Portable	Regular	SALE
IC-505 3/10W 6m SSB/CW portable	449.00	399^{95}
BP-10 Internal Nicad battery pack	79.50	
BP-15 AC charger	12.50	
EX-248 FM unit	49.50	
LC-10 Leather case	34.95	

VHF/UHF base multi-modes	Regular	SALE
IC-551D 80W 6-meter SSB/CW	699.00	599^{95}
EX-106 FM option	125.00	112^{95}
BC-10A Memory back-up	8.50	
SM-2 Electret desk microphone	39.00	
IC-271A 25W 2m FM/SSB/CW	699.00	569^{95}
AG-20 Internal preamplifier*	56.95	
IC-271H 100W 2m FM/SSB/CW	899.00	759^{95}
AG-25 Mast mounted preamplifier*	84.95	
IC-471A 25W 430-450 SSB/CW/FM xcvr	799.00	699^{95}
AG-1 Mast mounted preamplifier*	89.00	
IC-471H 75W 430-450 SSB/CW/FM	1099.00	969^{95}
AG-35 Mast mounted preamplifier*	84.95	

For a Limited time!
With the purchase of an IC-271A/H or IC-471A/H get the matching PREAMP* for only • $1.00 Extra.

Accessories common to 271A/H and 471A/H		
PS-25 Internal power supply for (A)	99.00	89^{95}
PS-35 Internal power supply for (H)	160.00	144^{95}
PS-15 External power supply	149.00	134^{95}
SM-6 Desk microphone	39.00	
EX-310 Voice synthesizer	39.95	
TS-32 CommSpec encode/decoder	59.95	
UT-15 Encoder/decoder interface	12.50	
UT-15S UT-15S w/TS-32 installed	79.95	

VHF/UHF mobile multi-modes	Regular	SALE
IC-290H 25W 2m SSB/FM, TTP mic	549.00	479^{95}
IC-490A 10W 430-440 SSB/FM/CW	649.00	579^{95}

VHF/UHF/1.2 GHz FM	Regular	SALE
IC-27A Compact 25W 2m FM w/TTP mic	369.00	299^{95}
IC-27H Compact 45W 2m FM w/TTP mic	409.00	359^{95}
IC-37A Compact 25W 220 FM, TTP mic	449.00	329^{95}
IC-47A Compact 25W 440 FM, TTP mic	469.00	399^{95}
PS-45 Compact 8A power supply	112.95	99^{95}
UT-16/EX-388 Voice synthesizer	29.95	
SP-10 Slim-line external speaker	29.95	
IC-3200A 25W 2m/440 FM w/TTP	549.00	489^{95}
UT-23 Voice synthesizer	29.95	
AH-32 2m/440 Dual Band antenna	32.95	
Larsen **PO-K** Roof mount	20.00	
Larsen **PO-TLM** Trunk-lip mount	20.18	
Larsen **PO-MM** Magnetic mount	19.63	
IC-1271A 10W 1.2 GHz SSB/CW Base	999.00	889^{95}
ATV-1200 ATV interface unit	TBA	
PS-25 Internal power supply	99.00	89^{95}
EX-310 Voice synthesizer	39.95	
UT-15S CTCSS encoder/decoder	79.95	
IC-120 1W 1.2 GHz FM Mobile	499.00	449^{95}
ML-12 1.2 GHz 10W amplifier	339.00	299^{95}

Repeaters	Regular	SALE
RP-3010 440 MHz, 10W FM, xtal cont.	999.00	899^{95}
RP-1210 1.2 GHz, 10W FM, 99 ch. synth	1199.00	1089
Duplexer 1210 1.2 GHz duplexer	1199.00	1089
Cabinet for RP-1210	249.00	

Order Toll Free
Use your Credit Card!

Hand-held Transceivers Deluxe models	Regular	SALE
IC-02AT for 2m	349.00	289^{95}
IC-04AT for 440 MHz	379.00	319^{95}

Standard models	Regular	SALE
IC-2A for 2m	239.50	189^{95}
IC-2AT with TTP	269.50	199^{95}
IC-3AT 220 MHz, TTP	299.95	239^{95}
IC-4AT 440 MHz, TTP	299.95	239^{95}

Accessories for Deluxe models	Regular
BP-7 425mah/13.2V Nicad Pak - use BC-35	67.50
BP-8 800mah/8.4V Nicad Pak - use BC-35	62.50
BC-35 Drop in desk charger for all batteries	69.00
BC-60 6-position gang charger, all batts **SALE**	359.95
BC-16U Wall charger for BP7/BP8	10.00
LC-11 Vinyl case	17.95
LC-14 Vinyl case for Dlx using BP-7/8	17.95
LC-02AT Leather case for Dlx models w/BP-7/8	39.95

Accessories for both models	Regular
BP-2 425mah/7.2V Nicad Pak - use BC35	39.50
BP-3 Extra Std. 250 mah/8.4V Nicad Pak	29.50
BP-4 Alkaline battery case	12.50
BP-5 425mah/10.8V Nicad Pak - use BC35	49.50
CA-2 Telescoping 2m antenna	10.00
CA-5 5/8-wave telescoping 2m antenna	18.95
FA-2 Extra 2m flexible antenna	10.00
CP-1 Cig. lighter plug/cord for BP3 or Dlx	9.50
DC-1 DC operation pak for standard models	17.50
LC-2AT Leather case for standard models	34.95
RB-1 Vinyl waterproof radio bag	30.00
HH-SS Handheld shoulder strap	14.95
HM-9 Speaker microphone	34.50
HS10 Boom microphone/headset	19.50
HS-10SA Vox unit for HS-10 & Deluxe only	19.50
HS-10SB PTT unit for HS-10	19.50
ML-1 2m 2.3w in/10w out amplifier **SALE**	79.95
SS-32M Commspec 32-tone encoder	29.95

Receivers	Regular	SALE
R-7000 25-2000 MHz, 117V AC	899.00	789^{95}
RC-12 Infrared remote controller	TBA	
R-71A 100 kHz-30 MHz, 117V AC	$799.00	649^{95}
RC-11 Infrared remote controller	59.95	49^{95}
FL-32 500 Hz CW filter	59.50	
FL-63 250 Hz CW filter (1st IF)	48.50	
FL-44A SSB filter (2nd IF)	159.00	144^{95}
EX-257 FM unit	38.00	
EX-310 Voice synthesizer	39.95	
CR-64 High stability oscillator xtal	56.00	
SP-3 External speaker	49.50	
CK-70 (EX-299) 12V DC option	9.95	
MB-12 Mobile mount	19.50	

MasterCard VISA (1)

HOURS • Mon. thru Fri. 9-5:30; Sat. 9-3
Milwaukee **WATS** line: **1-800-558-0411** answered evenings until 8:00 pm Monday thru Thursday.
Please use WATS lines for Ordering
use Regular lines for other Info and Service dept.

All Prices in this list are subject to change without notice.

Order Toll Free: 1-800-558-0411
In Wisconsin (outside Milwaukee Metro Area) 1-800-242-5195

AMATEUR ELECTRONIC SUPPLY ® *Inc.*

4828 W. Fond du Lac Avenue; Milwaukee, WI 53216 - Phone (414) 442-4200

AES BRANCH STORES

WICKLIFFE, Ohio 44092
28940 Euclid Avenue
Phone (216) 585-7388
Ohio WATS 1-800-362-0290
Outside Ohio 1-800-321-3594

ORLANDO, Fla. 32803
621 Commonwealth Ave.
Phone (305) 894-3238
Fla. WATS 1-800-432-9424
Outside Florida 1-800-327-1917

CLEARWATER, Fla. 33575
1898 Drew Street
Phone (813) 461-4267
No In-State WATS
No Nationwide WATS

LAS VEGAS, Nev. 89106
1072 N. Rancho Drive
Phone (702) 647-3114
No In-State WATS
Outside Nevada 1-800-634-6227

Associate Store

CHICAGO, Illinois 60630
ERICKSON COMMUNICATIONS
5456 N. Milwaukee Avenue
Phone (312) 631-5181
Outside Illinois 1-800-621-5802

AEAEAEAEAEAEAEAEAEAEAEAEA
AEAEAEAEAEAEAEAEA
AEAEAEAEAE
AEAE

DOCTOR QSO T.M.

Relieves All Symptoms Of Morse Code Phobia!

$79.95 AM NET

A Realistic Simulation of On-the-Air, Two-Way Morse Code 'Ragchew' Contacts (QSOs).

- **Makes Upgrading of Morse Skills Easy and Fun**
- **Does Away With Drudgery**
- **Skilled Operators Enjoy the Realism**
- **Operate Anytime—Requires Only a Commodore C-64 (or C-128) and A TV Set**
- **Removes the "Mystery" of what to Say in On-the-Air Contacts**
- **Excellent Practice for Beginners and Old "Pro's"**
- **Standard Format and Common Abbreviations Used for All Exchanges**
- **Send Morse with your keyboard**
- **Select Appropriate QRM and QRN Levels**
- **Select the Portion of the 'Band'—Novice or Low End**

Prices and Specifications Subject to Change Without Notice or Obligation

ADVANCED ELECTRONICS APPLICATIONS, INC.
P.O. Box C-2160, Lynnwood, WA 98036

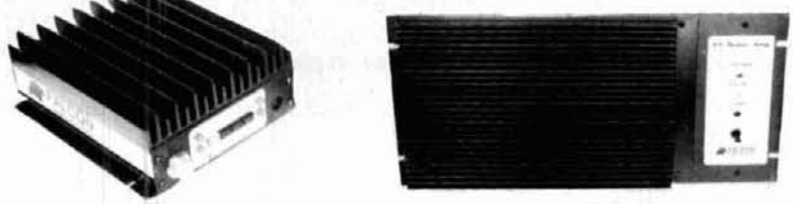
TELEX: 6972496
AEA INTL UW
(206) 775-7373

AEA BRINGS YOU THE BREAKTHROUGH

AEAEAEAE
AEAEAEAEAEAE
AEAEAEAEAEAEAEAE
AEAEAEAEAEAEAEAEAEAEAE

✓ 184

FALCON COMMUNICATIONS



Falcon Communications, Well Known for MOSFET Repeater Power Amplifiers, Also Makes A Hard Working Line Of Bipolar Power Amplifiers For Mobile Use. Our 2 Meter Amplifiers Include:

Model 5121	2 Watts in = 150 out 1 Watt in = 90 out	List $285
Model 5122	10 Watts in = 150 out 2 Watts in = 50 out	List $275
Model 5123	30 Watts in = 150 out 10 Watts in = 90 out	List $235
Model 6126	10 Watts in = 75 out 2 Watts in = 30 out	List $170
Model 4109	plug in receive pre-amp 12 db gain 2 db noise figure	List $36

A FEW FEATURES:

1) Made in the USA
2) All mode (FM, SSB, CW)
3) Optional plug-in receive preamp
4) Automatic COR or remote keying
5) Built in thermal protection
6) Full 1 Year warranty

For Information On Our Complete Line See Your Local Dealer Or Call Factory Direct

P.O. Box 8979 • Newport Beach, CA 92658
(714) 760-3622

STILL LOOKING FOR QUALITY

WIRE & CABLE

AT THE RIGHT PRICE?

RG-213 MIL SPEC, 97% SHIELD	28.5¢/ft
RG-214 MIL SPEC, DBL SILVER SHIELD	$1.50/ft
RG-174 MIL SPEC, 97% SHIELD	10¢/ft
RG-8X (MINI 8) FOAM, 95% SHIELD	12.5¢/ft
RG-8U FOAM, 95% SHIELD	24.5¢/ft
RG-58A/U MIL SPEC, 97% SHIELD	12¢/ft
RG-11A/U MIL SPEC, 97% SHIELD	28¢/ft
RG-59U MIL SPEC, 97% SHIELD	12¢/ft
300 OHM KW TWIN LEAD	16/ft
450 OHM HD LADDER LINE, POLY INS	10¢/ft
450 OHM HD LADDER LINE, BARE, 100 ft ROLL	$13.00
4 CONDUCTOR ROTOR CABLE	8¢/ft
6 CONDUCTOR ROTOR CABLE	14¢/ft
8 CONDUCTOR ROTOR CABLE (2#18/6#22)	16.5¢/ft
8 CONDUCTOR ROTOR CABLE HD (2#16/6#18)	34¢ ft
14 GA STRANDED COPPERWELD, 70 ft ROLL	$6.50
14 GA STRANDED COPPERWELD, 140 ft ROLL	$12.00
14 GA HD STRANDED COPPER	8¢/ft *
12 GA HD SOLID COPPERWELD	10¢/ft *
14 GA HD SOLID COPPERWELD	8¢/ft *
18 GA HD SOLID COPPERWELD	4¢/ft *

**SOLD IN CONTINUIOUS LENGTHS TO 5000 FT. IN 50 FT. MULTIPLES ONLY.*

LA CUE, INC.

132 Village Street
Johnstown, PA 15902
orders only
1-800-637-3300

✓ 142

STATE OF THE ART

The ARRL 1986 Handbook For The Radio Amateur carries on the tradition of the previous editions by presenting 1192 pages of comprehensive information for the radio amateur, engineer, technician and student. Paper edition: **$18** in the U.S., **$19** in Canada, and elsewhere. Clothbound **$27** in the U.S., **$29** in Canada and elsewhere.

THE AMERICAN RADIO RELAY LEAGUE
225 MAIN ST.
NEWINGTON, CT 06111

✓ 175

quartz crystal resonators

Learn how to specify crystals using frequency/temperature relationships

This article provides tools for specifying, testing, and controlling the parameters of piezo-electric crystals. This data is designed to allow you to specify your requirements exactly to the crystal supplier. Also included are TI-55-II calculator programs showing examples that reduce the burden of calculations.

The article is based on practical experience with thousands of crystals used in the communications industry. Because of the competitive nature of the business and the large quantities involved, crystals must be both low in cost and usable, in that they must be capable of being placed on the specified frequency and remain on frequency (within the limits specified) despite changes in both time and temperature.

the crystal impedance meter

When crystals are ordered from catalogs, problems frequently arise. Invariably the crystals quoted are to a military specification. There is nothing wrong with this as long as the circuit in which the crystal has to work matches it and provides the exact conditions specified. In practice this is generally not the case, and as a result, crystals that arrive may be within the specifications when tested in the standard Crystal Impedance (CI) meter, but may not meet your requirements when used in the actual oscillator circuit.

A quick look at some typical crystals listed in a vendor's catalog can give us some clues. We find among the specifications a variety of capacitances quoted. The values shown are frequently relics from the days of vacuum tubes and are used in the CI meter, selectable by a switch. This is all very convenient; the CI meter, however, looks at the crystal and measures it as an impedance — hence its name, "crystal impedance" meter. It is therefore not operating under the conditions that an oscillator places on it. You will also note that some crystals are series resonant. In this case, there is no loading capacitor, because the crystal is being driven and is operating into a purely resistive load. These crystals are thus on frequency only if used under those conditions.

As we go above 20 MHz, we get into the realm of overtone crystals. These crystals are, however, not an exact third or fifth or higher multiple of the fundamental. If the use of multipliers is to be avoided, these crystals can serve a very useful purpose, but there are advantages and disadvantages that must be considered.

example using 10-MHz crystal

We will now look at a typical requirement and consider a crystal that operates at 10 MHz in the parallel or antiresonant mode. (The series configuration is referred to as the resonant mode.) The crystal will therefore operate with a loading capacitance of 20 pF and in the fundamental mode. The crystal cut will typically be AT-cut, operating temperature 78.8 degrees F (26 degrees C) and frequency tolerance ± 20 ppm (other specifications we will consider later.) After obtaining samples from three different vendors and measuring them in the CI meter, we found each crystal to be at 10.000150 MHz, thus 15 ppm high. All crystals meet specifications, appear to be identical. However, all are not identical because the compliance, C_S has values of 0.01, 0.02, and 0.04 pF, respectively. (C_S, L, and R are inherent in the crystal.) **Figure 1** shows the electrical equivalent; this is the crystal without any electrodes attached. Inductance L is the electrical equivalent of the crystal mass. Capacitor C_S is the compliance and R is due to the losses by mechanical friction of the crystal. This electrical circuit is series resonant. **Figure 2** shows the crystal with its deposited electrical contacts. This is achieved by placing a small spot of a conducting material, such as silver, on each

By Peter Boddaert, 11 Blossom Road, Braintree, Massachusetts 02184

table 1.

C_S (pF)	C_L (pF)	$C_S/2C_L$ (pF)	F_S (MHz)	F_P (MHz)	ΔF (Hz)	L (mH)
			crystal 1			
0.01	31	0.0001613	9.998243	9.999855	- 145	
0.01	26	0.0001923	9.998243	10.000166	+ 166	25.339
0.01	21	0.0002381	9.998243	10.000624	+ 624	
total pulling = 769 Hz = ±38.5 ppm						
			crystal 2			
0.02	31	0.0003226	9.996310	9.999535	- 466	
0.02	26	0.0003845	9.996310	10.000154	154	12.674
0.02	21	0.000476	9.996310	10.001068	1068	
total pulling = 1533 Hz = ±76.665 ppm						
			crystal 3			
0.04	31	0.0006452	9.992487	9.998934	- 1068	
0.04	26	0.0007692	9.992487	10.000174	+ 176	6.342
0.04	21	0.0009524	9.992487	10.002004	+2,004	
total pulling figure = 2,004 + 1066 = 3070 Hz = ±153.5 ppm						

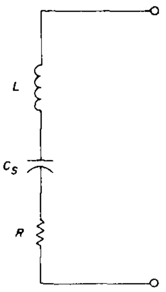


fig. 1. Crystal blank showing relationship of parameters inherent in the crystal: compliance, C_S; electrical equivalent of the crystal mass, L; and losses caused by mechanical friction of the crystal, R.

side and making electrical connections to these. As a result a capacitor is now formed, which together with the holder C, appears in parallel with the series resonant circuit, producing a parallel or antiresonant circuit. This capacitance is shown as C_P with a typical value of 6 pF. C_L is the load capacitance of 20 pF. The crystal thus sees the sum of C_P and C_L = 26 pF as a total load capacitance. In a practical circuit C_L is usually made variable so that the oscillator can be adjusted to frequency. A trimmer capacitor typically provides a minimum variation from 15 to 25 pF. Thus the actual load capacitance can vary between 21 and 31 pF.

We will now calculate the pulling figure or pulling ability of each crystal using the above values of loading C for each of the three crystals. We will also calculate the series resonant frequency, F_S, and the value for L. (See **table 1.**)

A convenient formula for parallel-resonant frequency is

$$F_P = F_S \ [1 + (C_S/2C_L)] \quad \textbf{(1)}$$

We see that the pulling ability or the ability to place the oscillator on frequency, is greatly influenced by C_S. Failure to control its value can result in being unable to place units on frequency without making modifications or, if the C_S is large such as in crystal 3, the pulling ability can become excessive. Such crystals are prone to frequency jump more so than those that have a smaller value of C_S. It must be remembered that *all* crystals have spurious responses not too far removed from the desired frequency. Such spurs can show up under certain conditions such as when a change in temperature occurs. A simple rule of thumb is: a crystal has a maximum pulling ability of 100 ppm.

We find that crystal 2 meets our requirement of being able to set it to frequency with a sufficient amount of overlap at each end. Crystal 1 would also be suitable; however, at the low end, things are tight. Allowing for component variations in production, together with the fact that the crystal frequency could be higher by another 50 Hz and still be within specifications, it would be desirable to be able to reject those at the incoming inspection. A simple solution to this problem is to specify pulling ability rather than the loading capacitance. The crystal specification would include:

- The frequency.
- Pulling ability in the test circuit (minimum = ±35 ppm, maximum = ±85 ppm).
- Approximate loading capacitance (*for reference only*), 20 pF.

There is, therefore, no reference to frequency tolerance because this is now taken care of by the pulling ability. In addition, the value of the loading capacitance is now used as a general guideline rather than an absolute value.

Of course, the vendor must now be supplied with a test circuit. This will consist of the complete oscillator plus all of its associated circuitry; an isolating stage, mixer, and such. It must be identical with the production units. Keep in mind that any test equipment such as a frequency counter connected to the circuit will have some influence on it, so the coupling must be as loose as possible to minimize these effects. Also be aware that any tuned circuits may have some effect on the frequency. Before shipping the test circuit to your supplier, check for the correlation between it and the in-house standard. There are bound to be some variations between them, and allowance must be made for this.

the overtone crystal

As mentioned, the overtone crystal operates on an odd harmonic of its resonant frequency such as third, fifth, seventh and higher. These crystals are more frequently employed in the series-resonant mode (although they can, of course, also operate in the parallel mode). C_S is extremely small. For example, in a fifth overtone crystal, C_S is on the order of 0.0005 pF at 70 MHz. Hence these crystals are much more difficult to pull on frequency by using a capacitor and consequently, are relatively unaffected by changes in the rest of the circuit because of temperature variations. With these crystals, however, a test circuit should be used and supplied to the vendor.

drive level

In general, crystal levels should be kept low. Some manufacturers specify a maximum level for AT-cut crystals operating in the fundamental mode, as 5 milliwatts. But whatever the maximum level quoted, it is better and safer to stay well below that value for a number of reasons:

- Excessive drive levels can break the crystal.
- The frequency stability is poor because of crystal heating, which causes excessive drifting.
- The crystal is much more susceptible to jump frequency or to operate on one of the crystal spurs, or to deliver an output at two or more frequencies simultaneously. These effects are most likely to show up with temperature variations.
- Note that the drive level will have some effect on the frequency; generally, doubling drive level will cause 2 ppm change.

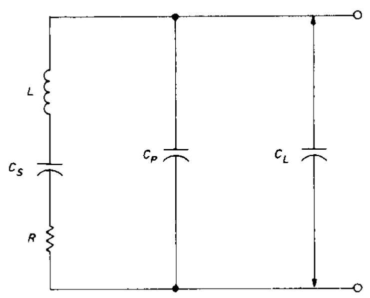


fig. 2. Crystal mounted in holder. C_S; is the loading capacitance.

frequency-temperature characteristics

The AT-cut crystal has been cut at an angle of 35 degrees. **Figure 3** shows the frequency/temperature/angle-of-cut characteristics. Note that the turnover points are placed almost symmetrically on either side of the center point, 79 degrees F (26 degrees C). For example, with the cut at +20 minutes, the upper turnover point (UTP) is at 223 degrees F (106 C) and the lower turnover point (LTP) is at −47 degrees F (−44 C). Thus at 144 degrees F (80 C) and −126 degrees F (−70 C), they are on either side of the center point.

At times, then, one would specify these points — for example, if the crystal were to be placed in an oven that operates at, say 176 degrees F (80 degrees C). It would then be a good policy to have the crystal *on frequency at the turnover point* of 176 degrees F (80 C), for at that point the rate of change is least, thus improving frequency stability. Bear in mind, however, that components that are not temperature controlled, but form a part of the frequency-determining network, will still have an influence on frequency stability; thus, if at all possible, they too should be inside the oven.

Another frequently called specification states that the frequency must be within ±10 ppm over the temperature range of 158 degrees F (70 C) to −22 degrees F (−30 C). Inspection of **fig. 3** shows that the cut at +4 minutes can meet this, but only barely. There is no margin for error in the angle of cut or for external component changes or tolerances. As a consequence, in the test area, the rejection rate is likely to be high. Generally, oscillators of this nature incorporate some form of temperature correction circuit consisting of thermistors or varactor diodes.

Unfortunately, these circuits invariably have to be adjusted during test, thus causing an added expense.

using NTC capacitors

Figure 4 shows a typical oscillator. Assuming the capacitances due to the transistor are small and can be ignored, we have a 20 pF loading capacitance made

table 2. Results.

temperature	−2.0 F (−19 C)	25 F (−4 C)	52 F (11 C)	79 F (26 C)	106 F (41 C)	133 F (56 C)	160 F (71 C)
F_P (MHz)	9.999804	9.999879	9.999954	10.000031	10.000109	10.000189	10.000270
ΔF (ppm)	−19.550	−12.137	−4.589	3.045	10.914	18.866	26.951
C_L (pF)	21.755	21.059	20.385	19.732	19.101	18.490	17.899

table 3. Corrected figures.

temperature	−2.0 F (19 C)	25 F (−4 C)	52 F (11 C)	79 F (26 C)	106 F (41 C)	133 F (56 C)	160 F (71 C)
ΔF (ppm)	−22.595	−15.182	−7.634	0	7.869	15.821	23.906

up by the trimmer in series with the two 150-pF capacitors. Most mobile radio equipment is required to operate over the temperature range of −22 degrees F (−30 degrees C) to 158 degrees F (70 C). Thus with a total temperature change of 180 degrees F (100 C) the N2200 capacitors will change by: TC × change in degrees F × 5/10,000 × 9 equals percent. (TC × change in degrees C/10,000 = percent), where TC is the temperature coefficient. Thus 2200 × 100/10,000 = 22 percent, so that the total value of the two 150-pF capacitors in series = 75 ± 11 percent. At −22 degrees F (−30 C) the capacitance is 83.25 pF; at 158 degrees F (70 C) it is 66.75 pF.

The trimmer, which has a value of 27 pF, will change by 7.5 percent over the temperature range, thus at −22 degrees F (−30 C) it will be 28.01 pF and at 158 degrees F (70 C) it will be 25.99 pF. The total C that the crystal thus works into at 158 F (70 C) is the series combination of 66.75 + 25.99 pF in parallel with a C_P of 6 pF, or a total of 18.71 + 6 = 24.71 pF. At −22 degrees F (−30 C) this becomes 20.96 + 6 pF = 26.96 pF.

If we use these capacitors in conjunction with crystal 2, which has a C_S of 0.02 pF and F_S = 9.99631 MHz, we thus obtain F_P at 158 F (70 C) = F_S × 1.0004048 = 10.000357 MHz, and at −22 F (−30 C) = F_S × 1.0003709 = 10.000018 MHz. The total frequency change thus brought about = 339 Hz, a variation of 33.9 ppm. With the help of **fig. 3**, we can now locate a crystal that has its turnover points at ±17 ppm. The chart shows an 8 minutes cut to be close, with turnover points at −11.2 degrees F and 168.8 degrees F (−24 C and 76 C, respectively) and a frequency variation of + and −20 ppm. The frequency changes due to the crystal would thus be reduced to approximately ±3 ppm by the use of NTC capacitors, a very worthwhile improvement obtained without any increase in cost or number of components. Of course, the example given here is not the only combination. Had we chosen crystal 3, with a C_S of 0.04 pF, we would have obtained twice as much pulling ability, and thus use capacitors with a smaller NTC. Using a 12 minute angle places the turnover points further out thus extending the usable temperature range of the oscillator. Do not, however, lose sight of the fact that any circuit variations brought about by temperature changes will have an effect on the frequency so that bypass capacitors, layout and component placement, and good engineering principles must be taken into account.

long-term stability

Some manufacturers publish figures for their crystals. In general the cold weld type holder will have better long-term stability. It is not easy to determine as it is a matter of time; however, to achieve the greatest stability the oscillator should operate continuously. It should also be subjected to a program of temperature cycles with the oscillator operating before setting it to frequency. How much aging can one expect? It is not unreasonable to look for a ±3 ppm/year figure, which in most applications is very acceptable.

resistance and temperature

The series resistance of the AT-cut crystal tends to go down in value as the frequency increases when operating in the fundamental mode. With overtone-mode crystals the reverse occurs. In the range of 5 to 20 MHz, a maximum value of 50 ohms is reasonable. Overtone crystals tend to have series R values about 50 percent higher. The resistance tends to be temperature sensitive and can easily double in value at 158 F (70 C). In some cases this could lead to oscillator failure or to a considerable reduction in output power. Specifying the maximum R over the operating temperature range rather than at 79 F (26 C) can avoid any misunderstandings with the manufacturer over this matter. Keep in mind, however, that over-specifying costs money. The tighter the specifications, the

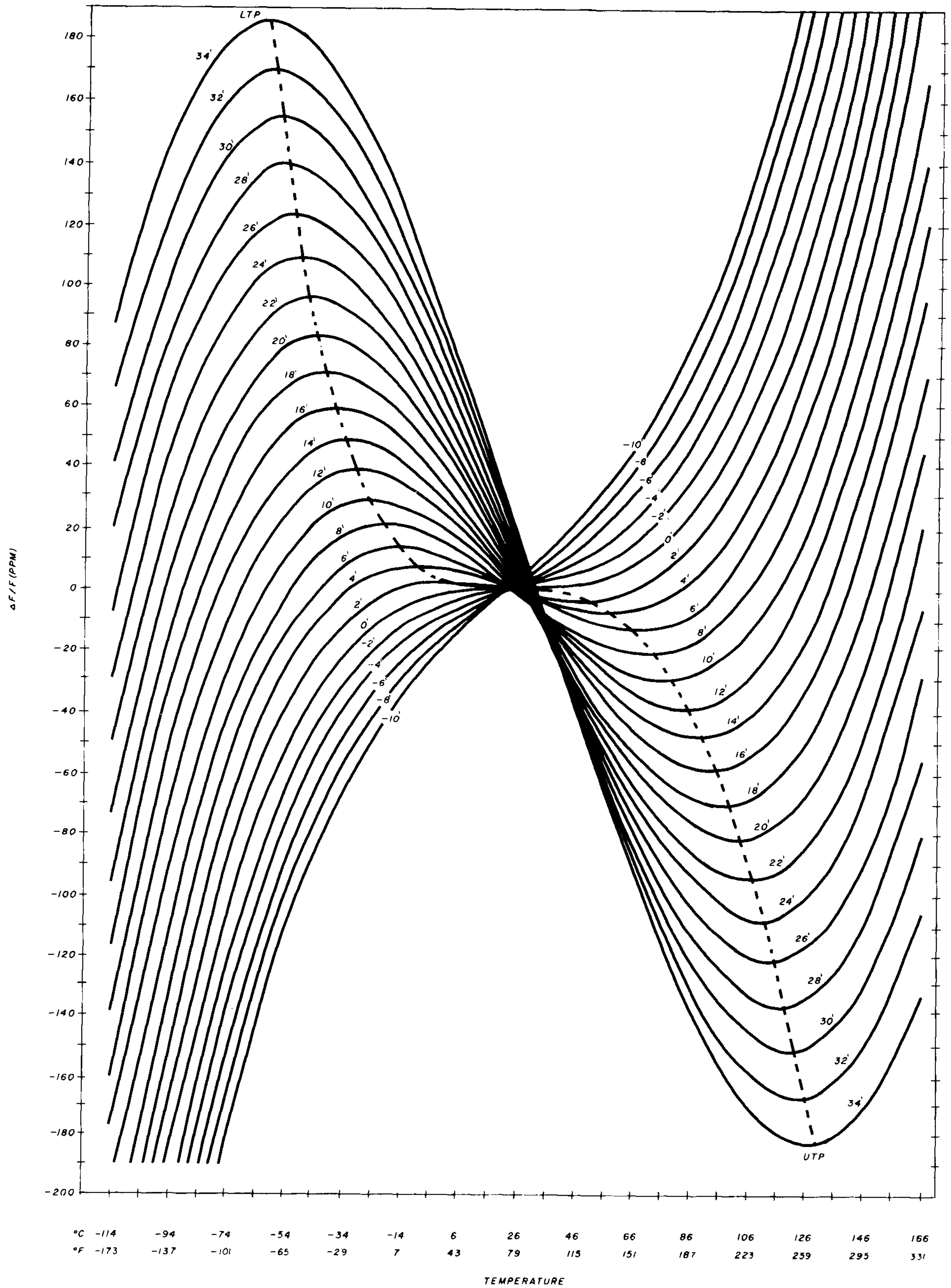


fig. 3. Frequency/temperature angle of cut characteristics for quartz crystal resonators. LTP and UTP are respectively lower and upper turnover points. Chart is for AT-cut crystals.

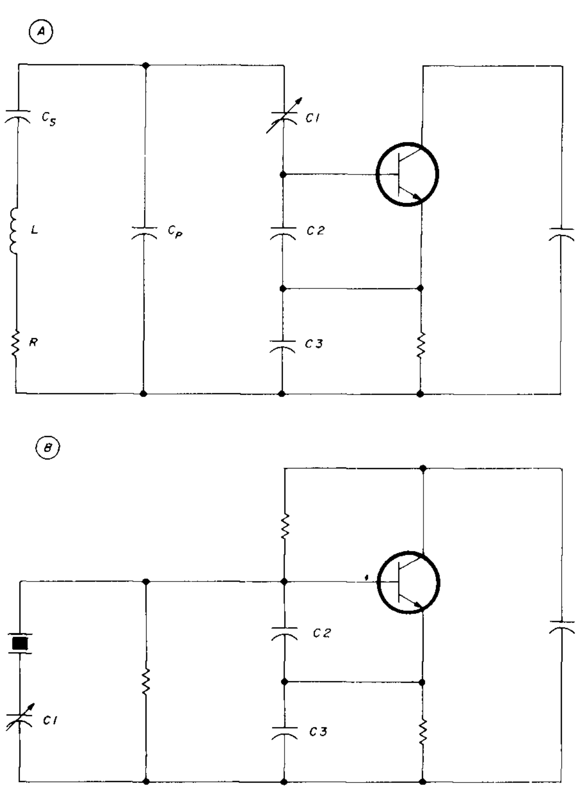


fig. 4. (*A*) is a typical oscillator with a 20 pF loading capacitance made up by the trimmer, C1 in series with two 150 pF capacitors, C2 and C3. In (*B*) a practical circuit in the parallel-resonant mode is shown. Trimmer C1 now has its rotor grounded, making it cold in terms of RF. Bias resistors are also shown.

more expensive the product. Very low series R is also possible, which in some cases can lead to oscillator squegging. Placing a lower limit on the R value can avoid this problem.

spurious responses

As mentioned earlier, all crystals have a number of resonances at unwanted frequencies and in some instances located close to the desired frequency. In some situations this can present a problem, with the oscillator suddenly jumping to one of these. A consultation with the vendor on this matter and a thorough testing of the initial design for this potential trouble is most desirable. If necessary the spurious response characteristics of the crystal should be included in the specifications. Experience shows that these precautions can save a lot of headaches later on.

vendor selection

The vendor is most important; good rapport is essential. Make it clear at the onset that you will not accept units that fail to meet the specifications and that he owns *all* rejects no matter how large the quantity. Also let him know that you intend to conduct inspection tests for compliance to specifications. For small quantities, every unit will be tested; for large quantities testing will be conducted on a sampling basis. The sampling method plus the amount of rejects found in the sample size before rejection should be explained and agreed upon by all concerned, because this will be part of the purchase contract.

Crystal manufacturers tend to specialize; consequently, the vendor who makes excellent low-frequency crystals may not produce the best high-frequency crystals. This can be especially true for overtone crystals so make sure that you select a vendor who demonstrates both the ability and willingness to produce crystals that consistently meet all your requirements. It is a mistake to press a supplier to make something that he is not really comfortable or experienced with; sooner or later, things will go wrong, spoiling a good relationship.

Today, computers and software that will determine the pulling ability of the crystals and print out a histogram of the results as well are easily available. A copy of this information sent to the supplier will enable him to make any slight modifications to his next production run if necessary.

determining F_P, ΔF, C_L

We have looked at quartz crystals in general and at some of the desirable parameters. I also proposed the use of NTC capacitors to compensate the frequency deviation of the crystal with temperature. I then showed that pulling ability is important, much more so than is generally realized. By placing a minimum/maximum limit on it, we get the Series C, a property of the crystal under manufacturing control, ensuring consistency of the product as well as the ability to place the crystal on frequency in our circuit and to apply temperature compensation.

In the previous example the minimum/maximum pulling ability was specified as ± 35 ppm and ± 85 ppm. Statistically the mean is thus ± 60 ppm. Inspection of the formula for F_P and the example crystals 1, 2, and 3 shows that the pulling ability of the crystal is directly proportional to the value of C_S.

Taking crystal 1 as an example with C_S at 0.01 pF and pulling ability at ± 38.5 ppm, then C_S for the average crystal with ± 60 ppm pulling ability = (60/38.5) $\times$ 0.01 = 0.016 pF. We can now also calculate F_S for this crystal using the formula for F_P and transposing: $F_S = F_P/[1 + C_S/2\ C_L]$, which, with F_P = 10 MHz and C_L = 26 pF = 9.996923 MHz. As this is the crystal we will be working with, and for easy reference, we place the parameters on one line: F_S = 9.996923 MHz, C_S = 0.016 pF, F_P = 10.000,000 MHz, $C_L + C_P$ = 26 pF.

table 4. Results.

temperature	-2.0 F (-19 C)	25 F (-4 C)	52 F (11 C)	79 F (26 C)	106F (41 C)	133 F (56 C)	160 F (71 C)
crystal 8′ (ppm)	21	18	10	0	-10	-17	-21
corrected (ppm)	-22.595	-15.182	-7.634	0	7.869	15.821	23.906
error (ppm)	-1.595	2.818	2.366	0	-2.131	-1.179	2.906

table 5. Results.

temperature	2.0 F (-19 C)	25 F (-4 C)	52 F (11 C)	79 F (26 C)	106 F (41 C)	133 F (56 C)	160 F (71 C)
F_P (MHz)	9.999905	9.999945	9.999985	10.000026	10.000067	10.000108	10.000150
ΔF (ppm)	-9.474	-5.485	-1.460	2.604	6.704	10.842	15.017
C_L (pF)	20.817	20.463	20.115	19.773	19.437	19.107	18.782

table 6. Corrected figures.

temperature	-2.0 F (-19 C)	25 F (-4 C)	52 F (11 C)	79 F (26 C)	106 F (41 C)	133 F (56 C)	160 F (71 C)
ΔF (ppm)	-12.078	-8.089	-4.064	0	4.1	8.238	12.413

Next, determine and tabulate the values of C_L, F_P, and the change of F_P (from that at 79 degrees F (26 C) in frequency and ppm with temperature. Except for the frequency, it serves no practical purpose to tabulate beyond three decimal points; similarly, there is little to be gained in making the temperature steps closer than 27 degrees. An operating range of 81 degrees F (45 C) above and below 79 degrees (26 C) is sufficient for most applications.

capacitors with N2200 temperature coefficients

In the following example, C1, C2, and C3 have an N2200 temperature coefficient. And since they are all in series (**fig. 4A**) it is a simple matter to calculate C_L at 79 degrees F (26 C). $C_L = 1/(1/27 + 1/75) = 1/(0.0370 + 0.0133) = 19.853$ pF. Next, calculate the new value of C_L at a temperature 27 degrees F (15 C) below 79 degrees F (26 C). We can use either the formula above or use the calculator program shown in **appendix A**. As this calculation is very simple (there being no mixture of TCs) we will use the formula, thus: $2200 \times 15/10{,}000 = 3.3$ percent. The new capacitive value is $= 19.853 \times 1.033 = 20.508$ pF. That is, for every 27 F (15 C) degree decrease in temperature, the capacitance increases by 3.3 percent. Conversely, the capacitance decreases in value by 3.3 percent for every 27 F (15 C) degree increase in temperature. Hence the multiplier is then $1/1.033 = 0.968$. It is this value that is used in the calculator program in **appendix B** as the capacitance multiplier.

To use the program we enter in **lines 02, 03, 04** the capacitance multiplier 968 plus the other values as shown (which belong to the crystal.) We then start calculations by entering into the calculator display the value of C_L at 15 degrees C below the lowest temperature of interest, thus in the example at -60 C (ΔT), (-29 F or -34 C) $= 1.132 \times 19.853 = 22.47$ pF. *Note that the value of C_L at 79 degrees F (26 C) (19.853 pF) is not used in the program.*

We now have the calculated values of F_P in MHz at every 15-degree C interval as well as the change in F_P (ΔF) in ppm (**table 2**). We find at the 26-degree C point an error of 3.045 ppm. In practice, correction is by adjusting C1 to pull it on frequency. On paper, we do it by substracting 3.045 ppm from each figure (see **table 3**).

Our next step is to look at the curves of **figs. 3** and **5**. These are the frequency/temperature curves for AT-cut crystals. Note the dashed line which intersects the upper and lower turnover points with the various angles of cut. For our purpose, **fig. 5** is more convenient to use. Now project on this set of curves, at the -2.2 F (-19 C) point, the -22.595 ppm obtained from the corrected figures in **table 3**, but with a change of sign. Thus as a + quantity, it intersects the LTP just above the 8 minute cut and in the other direction, at 160 F (72 C), it is close to intersecting the UTP of a 9 minute cut.

A crystal with an LTP at -2.2 F (-19 C) of 22 ppm would appear to be our best bet, (approximately an 8 minute cut). Tabulating the figures for this crystal and subtracting the corrected figures from them, we obtain the results shown in **table 4**.

We have thus improved the frequency/temperature performance of the system from a maximum variation of 42 ppm to one with a change of 5.037 ppm, about an 8:1 improvement.

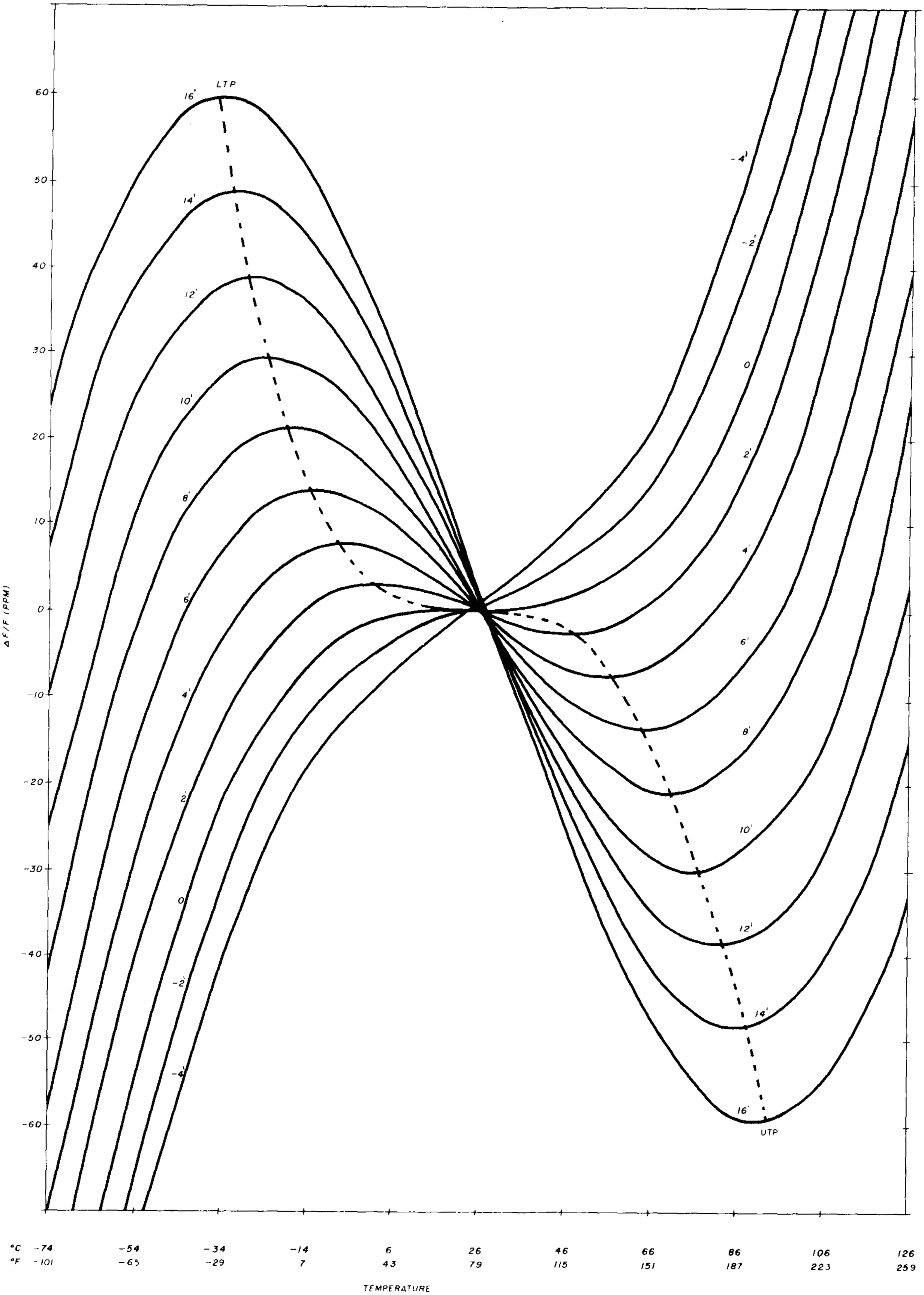


fig. 5. Frequency/temperature curves used to demonstrate crystal performance. (A text example. Chart is for AT-cut crystals.)

table 7. Results.

temperature	−2.0 F (−19 C)	25 F (−4 C)	52 F (11 C)	79 F (26 C)	106 F (41 C)	133 F (56 C)	160 F (71 C)
crystal 5.5′ (ppm)	12	11	7	0	−6.5	−11	−12
corrected (ppm)	−12.078	−8.089	−4.064	0	4.1	8.238	12.413
error (ppm)	−0.078	2.911	+2.938	0	−2.400	−2.762	0.413

N750 temperature coefficient material

In the next example, the TC of C1 is changed to an N750 material. Because we are now employing two different TC materials in the capacitors forming C_L it is easier to make use of the program in **appendix A**. Calculate the value of C_L at 15 C and at −60 C [−29 F (−34 C)] below 79 F (26 C). The rest of the calculations are the same as for our first example. The value of C_L at 79 F (26 C) is of course, still 19.853 pF. Capacitors C2 and C3, being identical and in series, are thus treated as one capacitor of 75 pF.

temperature		52° F (11°C)	−29° F (−34°C)
C1 (pF)	=	27.304	28.215
C2,3 (pF)	=	77.475	84.900
C_L (pF)	=	20.189	21.177

The capacitance multiplier = 20.189/19.853 = 1.017 and the value used in the calculator program is 1/1.017 = 0.983. Start the calculations by entering into the display C_L at −29 F (−34 C) = 21.177 pF.

We have now the calculated values of F_P (in MHz) (see **table 5**) at every 15 C-degree interval, also the change in F_P (ΔF) in ppm. We now correct for the shift at 79 F (26 C), by subtracting 2.604 from each reading see (**table 6**).

Turning now to the curves (**fig. 5**) locate at −2.2 F (−19 C) the +12.078 ppm point. This is located just below the +6 minutes cut, which has its LTP at 7 F (−14 C) and at the 13.5 ppm point. Thus a crystal, having an angle of cut just a fraction below this would probably be our best bet, a cut having its LTP at: 14 F (−10 C) degrees with +12 ppm (approximately a 5.5 minutes cut). Tabulating the figures for this crystal and subtracting the "corrected figures" from them, we obtain the results shown in **table 7**. We have thus improved the frequency/temperature performance from a 24 ppm change to 5.848 ppm, an improvement of 4:1.

summary

The improvement in frequency drift with temperature is considerable and obviously desirable. Instead of specifying the angle of cut, specify either the LTP or the UTP (whichever is more important), giving both the temperature and the amount of change desired from the 79 F (26 C) degree point. Since these points are easily measured using standard test equipment, the manufacturer decides on the angle of cut. Crystals tend to show hysteresis, or inability to retrace reverse conditions, so temperature/frequency measurement should always be made from the same direction in terms of temperature.

To obtain the greatest frequency stability with temperature and time variations, and if power conservation is of secondary importance, place the complete oscillator in a temperature controlled oven, specify the crystal frequency and the UTP at the oven temperature, and allow both to operate continuously.

Where power preservation is important, such as in portable equipment, use NTC capacitors to compensate the crystal and specify the upper and lower turnover points. Place the capacitors close to the crystal so that they also "feel" the same temperature, keeping them clear from heat generating parts.

Overtone crystals are frequently used in the resonant mode. It is generally desirable to tune out Cp with an inductance to prevent oscillations at a frequency determined by this capacitance. Frequency adjustment by the addition of a small amount of inductance is possible.

appendix A

TI-55-II programming

Calculates capacitance with change of temperature. Requires three data memories that contain the numerical values of C, the temperature change or the temperature coefficient, and the number 1,000,000. Displays the new capacitance value.

step	key	line no.	key code	remarks
1	x	00	65	
2	RCL	01	71	
3	1	02	01	memory 1, stores TC or temperature change
4	÷	03	55	
5	RCL	04	71	
6	2	05	02	memory 2, stores 1,000,000
7	=	06	95	
8	x	07	65	
9	RCL	08	71	
10	0	09	00	
11	=	10	95	memory 0, stores the value of C
12	−	11	75	
13	RCL	12	71	
14	0	13	00	
15	=	14	95	memory 0, stores the value of C
16	±	15	94	
17	RST	16	22	displays the new value of C and resets the calculator to start
18	LRN			takes the calculator out of the learning mode.

Now, key in the value of C(27) and STO in 0. Place TC(750) in STO 1 and 1,000,000 in STO 2. Clear display and press RST. Key into the display the temperature −50 C. press R/S. The display should show 28.0125, thus the capacitance increased with a reduction of −50 C *in temperature.*

Next place into the display 50, then R/S, and the display will show 25.9875, thus a decrease in capacitance with increasing temperature. Thus, by placing the TC of the capacitor into memory 1, and with the capacitor's value stored in memory 0, we can conveniently find the new value with any change of temperature. Interchanging TC with temperature, thus placing the temperature change in memory 1 and keying the TC into the display, will show the effect of changing TC on the capacitance value with various temperature coefficients.

appendix B

TI-55-II programming

Calculates and displays each new value of F_P, ΔF from F_P at 26 C *degree, and the new value of* C_L *(in pF). Note that F is shown in* + or − ppm. Requires three data memories. Memory 0 stores the new (decremented) value of C_L, memory 1 contains F_S in MHz (to six decimal places), and memory 2 contains the value of F_P at 26 degrees C also to six decimal places.

step	key	line no.	key code	remarks	example
1	×	00	65		
2	.	01	93		
3	*	02	*		9
4	*	03	*	enter: capacitive multiplier	6
5	*	04	*		8
6	=	05	95		
7	STO	06	61	memory 0 must be empty (0) at the start	
8	0	07	00		
9	+	08	85		
10	*	09	*	value of C_P (6 pF)	6
11	=	10	95		
12	×	11	65		
13	2	12	02		
14	=	13	95		
15	÷	14	55		
16	.	15	93		
17	*	16	*	value of C_S (0.016 pF)	0
18	*	17	*		1
19	*	18	*		6
20	x-y	19	52		
21	+	20	85		
22	1	21	01		
23	=	22	95		
24	×	23	65		
25	RCL	24	71	enter F_S in memory 1	9.996923
26	1	25	01		
27	=	26	95		
28	R/S	27	12		
29	-	28	75		
30	RCL	29	71	enter F_P at 26 degrees C in memory 2	10.000000
31	2	30	02		
32	−	31	95		
33	÷	32	55		
34	RCL	33	71		
35	2	34	02		
36	=	35	95		
37	2nd Eng	36	47		
38	R/S	37	12		
39	RCL	38	71		
40	0	39	00		

End of program. Automatically resets and displays the new value of C_L, which is now in memory 0.

To start, press RST, enter F_S *in memory 1 and* F_P *in memory 2.* Check that memory 0 is 0. Enter into the display the value of C_L at −76 F (−60 C). Example 22.474. Press R/S. Displays F_P at −2 F (−19 C) = 9.999804. Press R/S, display −19.5507-06. This is the change in frequency from F_P at 26 C = −19.550 ppm. Press R/S, display = 21.754832 00; thus 21.755 pF, which is C_L at −2 F (−19 C). Press R/S again. This repeats the calculations, using this time C_L at −2 F (−19 C), calculates all the 25 F (−4 C) parameters, and so on, saving a lot of repeating calculations.

appendix C

TI-55-II programming

To calculate $F_P = F_S \; [1 + (C_S/2C_L)]$ requires four data memories that will contain the numerical values of C_S, C_L, F_S, and F_P at 26 C degrees in this order. In the same order will be displayed the values of $C_S/2C_L$, F_P and the difference between F_P and the F_P at 79 F (26 C), thus ΔF. Partition four memories and place the calculator in the learn mode.

step	key	line no.	key code	remarks
1	RCL	00	71	
2	0	01	00	memory 0 stores C_S
3	÷	02	55	
4	(	03	53	
5	2	04	02	
6	×	05	65	
7	RCL	06	71	
8	1	07	01	memory 1 stores C_L
9	)	08	54	
10	-	09	95	
11	R/S	10	12	displays value of $Cs/2C_L$
12	+	11	85	
13	1	12	01	
14	−	13	95	
15	×	14	65	
16	RCL	15	71	
17	2	16	02	memory 2 stores the value of F_S in MHz
18	-	17	95	
19	R/S	18	12	displays the value of F_P in MHz
20	-	19	75	
21	RCL	20	71	
22	3	21	03	memory 3 stores F_P at 26 C degree point, (thus with a total C_L at 26 pF). Example 10.000000 MHz)
23	=	22	95	
24	RST	23	22	displays the difference between F_P and the value contained in memory 3
25	LRN			takes calculator out of learning mode.

Key in the value of Cs (0.01) and STO in 0. Place C_L (26) in STO 1, F_S in STO 2, and in STO 3. Place 10,000,000. Now press ON/C to clear the display. Check the contents *of each memory* for errors. If OK again clear the display and press R/S *to run the program.* The first stop should be $Cs/2C_L$ = 0.0001923. Press R/S again, up comes F_P = 10.000166 and finally the frequency difference at 0.0001667 MHz. Press 2nd, Fix 6, which will fix the display to 6 decimal points.

ham radio

HOT ROD ANTENNA

Achieve 1 or 2 db gain over ANY ⅝ wave two meter telescopic antenna. The AEA model HR-1 Hot Rod™ antenna was designed by Dr. D.K. Reynolds (designer of the IsoPole) to deliver maximum performance for any hand-held transceiver with a BNC fitting.

The factory-tuned HR-1 is 20% shorter, lighter and places far less stress on your hand-held connector and case. It will easily handle over 25 watts of power, making it an excellent emergency base or mobile antenna. In the collapsed position, the Hot Rod antenna will perform like a helical quarter wave.

The Hot Rod antennas can be expected to make the same improvement to hand-held communications that the IsoPole brand antennas have made to base station operations. Why pay more when the best costs less?

Prices and Specifications subject to change without notice or obligation.

ADVANCED ELECTRONIC APPLICATIONS, INC.
P.O. Box C-2160,
Lynnwood, WA 98036
(206) 775-7373
Telex: 152571 AEA INTL

AEA Brings you the Breakthrough!

✓ 186

THE DICK SMITH ELECTRONIC ENTHUSIASTS CATALOG
132 PAGES CRAMMED WITH KITS • BOOKS • COMPONENTS • DATA • HAM GEAR AND MORE
PLUS BONUS COUPONS WORTH $2 REDEEMABLE OFF YOUR 1st ORDER

Rush me my copy of the Dick Smith Catalog, I enclose $1 to cover shipping

Name ....

Address..............................

City..............................

Zip ....

DICK SMITH ELECTRONICS INC.
P.O Box 2249 Redwood City CA 94063

216

ENGINEERING CONSULTING

583 CANDLEWOOD ST.
BREA, CALIFORNIA 92621

COM-SHACK 64
SIMPLEX AUTO-PATCH & REMOTE H.F. BASE

MODEL CS-64

$229.95

Includes Software (Program Disk), Hardware Interface & Instruction Manual

TELEPHONE
714-671-2009

• Simplex autopatch and H.F. remote base with clear voice messages • Control your Yaesu FT 757 transceiver with your VHF/UHF portable or mobile • Switch between the H.F. remote and the autopatch with DTMF tones • Voice ID & all control functions & H.F. frequency are voice announced with your programable access codes • Autopatch works on any telephone line — tone or dial pulse • Call waiting compatability — after beep answer second incoming call while on the patch! • Automatic redial last number (in dial pulse mode) • Ring detect & automatic voice alert of incoming telephone call • Inactivity timer turns off system (user programable) • Store 8 H.F. memory frequencies + shift VFO's & change bands • Fast scan & slow scan + dial up any frequency with DTMF tones all from your handheld VHF/UHF portable or mobile • Use the autopatch or the remote base both for the price of one! • User defined timing window, access codes, call sign • Simple to install hardware interface cables, connectors supplied • Hook mic input, PTT, spkr outputs & FM squelch connection 3 pin H.F. data cable and you are in control • You supply — 1 Commodore 64 or 128 & 1 disk drive + base station • No additional power supply required • With human voice synthesized by Covox™.

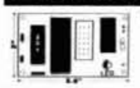
Send Check of M.O. to
ENGINEERING CONSULTING
583 CANDLEWOOD STREET
BREA, CA 92621

TOUCHTONE® DECODER KIT

MODEL TTK
$22.95

• SSI201 DTMF Receiver • Receive all 16 DTMF digits • No additional filtering • Output BCD or hex format • Low power (29 ma @ 12V) • Kit includes 3.58 Mhz crystal, 22 pin IC socket, resistor, capacitors, data sheet and schematics

4-DIGIT SEQUENCE DECODER



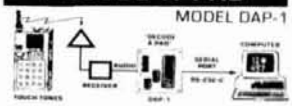
WIRED & TESTED
MODEL TSD
$59.95

• Completely wired & tested • User programable • LED status indicator • Open collector output • Control relays; mute audio • Control link on/off • Custom IC insures high reliability & small size! • Fits inside most rigs: runs on 12 VDC (35 ma) • All 16 digits allow more than 50,000 combinations • Makes excellent private call on busy repeaters! • Use it to turn on audio or sound an alarm • Momentary and latching outputs

Mastercard and Visa accepted
Prices include postage & handling, U.S.A.
California addresses add 6%.

"DECODE-A-PAD"

MODEL DAP-1



TOUCHTONE® DTMF to RS-232-C 300 BAUD INTERFACE
$89.95

• Use your computer to decode DTMF touchtones • Receive all 16 digits as fast as they can be transmitted • Easily program your computer in BASIC to decode multidigit "strings", display digits, sound alarms, observe secret codes, control relays • Simple to use; just provide +12 VDC and audio, hook two wires to the RS-232-C serial input on your computer, enter a simple BASIC program and begin to decode • Sample BASIC program and instructions included • Data indicator • Wired and tested

Send Check of M.O. to
ENGINEERING CONSULTING
583 CANDLEWOOD STREET
BREA, CA 92621

ICOM IC-02AT USER'S "AUDIO BLASTER" MODULE

1000's of Satisfied Customers — **Now Available for IC-2AT**

$19.95

• Module installs inside the radio in 10 minutes • Boost audio to nearly one watt! • Low power drain (4ma stand-by) • Complete step-by-step instructions included • Corrects the LOW audio problem! • Drive external speakers to full volume, even signals with low deviation!

TUNE THE WORLD FROM YOUR HANDHELD VHF/UHF RADIO
2 FOUR DIGIT DTMF DECODERS, PLUS 16 DIGIT KEYPAD CONTROL

Model RAP-1 **REMOTE-A-PAD®** **$149.95**

• Audio tones from any source, are converted to solid state switches which control any 16 digit keypad of a radio or other device • Some examples you can control include the Pro-Search™ Rotator (rotate beam remotely); Remote controls: ICOM IC-701 or ICOM IC-211 when using the RM-2 controller; Kenwood 7950 & 751; Azden PCS 4000; handhelds such as Yaesu FT-208; FT-708; ICOM IC-02AT; and many more... • Two (four-digit) programmable access codes are used to operate relays or other on/off functions • LED decoder status indicators and momentary plus steady state decoder outputs are provided • All CMOS low power drain (30ma); S.S.I. 201 Decoder • Hook eight wires (4 rows and 4 columns) in parallel with the existing keypad of the radio you wish to control remotely. Connect audio from any source, 12 volts D.C. and you are in control • The dual 4 digit decoders will turn your links on and off using your programmable access code.

AMATEUR RADIO MAIL LISTS
Self-stick 1x3 labels

*** NEWLY LICENCED HAMS ***
*** ALL NEW UPGRADES ***
*** UPDATED EACH WEEK ***

Total List = 462,728 (ZIP sorted)
Price is 2.5 cents each (4-up Cheshire)

BUCKMASTER PUBLISHING
Mineral, Virginia 23117
703:894-5777

✓ 172

MULTI-BAND SLOPERS

ALSO DIPOLES & LIMITED-SPACE ANTENNAS

Outstanding performance of W9INN antennas is well known! Now enjoy multiband BIG-SIGNAL reports! Automatic bandswitching • Very low SWR • Coax feed • 3kw power • Compact • FULLY ASSEMBLED to your specified center frequency each band • Easy to install • Very low profile • Complete instructions • Your personal check accepted

4 BAND SLOPER - 160, 80, 40, 30, or 20M	60 ft long	$ 48 ppd
3 " " - 160, 80, 40M	60 ft "	$ 43 "
2 " " - 80, 40M	40 ft "	$ 35 "
3 " NO-TRAP DIPOLE - 160, 80, 40M	113 ft long	$ 71 "
2 " " " " - 80, 40M	85 ft "	$ 55 "
9 BAND SPACE SAVER DIPOLE - 160 thru 10M*	46 ft long	$ 85 ppd

* Requires wide-range tuner (80, 40, 20, 15M without tuner)

SEND SASE for complete details of these and other unique antennas

W9INN ANTENNAS 312 394 3414
BOX 393-H MT. PROSPECT, IL 60056

✓ 103

NEMAL ELECTRONICS INTL., INC.

NOW AUTHORIZED BELDEN DISTRIBUTOR

your **one stop** coax supplier!

Exclusive

SATELLITE CONTROL CABLE

5 TYPES AVAILABLE! NEW!!! Lowest Loss

AVAILABLE IN 250-500-1000 FT. ROLLS OR BY THE FOOT

TYPE 1 (General Purpose)	TYPE 2 (MTI)	TYPE 3 (Intersat)	TYPE 4	TYPE 5
1 — RG59/U 96% Copper Braid 2 @ 16 Gauge 5 @ 22 Gauge 3 @ 20 Gauge Shielded plus Tinned Copper Drain Wire	1 — RG59/U 96% Copper Braid 2 @ 12 Gauge 3 @ 18 Gauge 3 @ 20 Gauge Shielded plus Tinned Copper Drain Wire 1 @ 22 Gauge Shielded plus Tinned Copper Drain Wire	2 — RG59/U 96% Copper Braid 2 @ 12 Gauge 6 @ 18 Gauge 3 @ 22 Gauge Shielded plus Tinned Copper Drain Wire	1 — RG6/U 18 Gauge 96% Copper Shield 2 @ 12 Gauge 3 @ 18 Gauge 3 @ 20 Gauge Shielded plus Tinned Copper Drain Wire 1 @ 22 Gauge Shielded plus Tinned Copper Drain Wire	2 — RG6/U 18 Gauge 96% Copper Shield 2 @ 12 Gauge 3 @ 18 Gauge Shielded plus Tinned Copper Drain Wire 3 @ 22 Gauge Shielded plus Tinned Copper Drain Wire
55¢ FT	75¢ FT	95¢ FT	79¢ FT	89¢ FT

Call for 1000 FT pricing

Designed for easy, one-step installation providing the required cables for most earth station equipment all in a direct burial jacket

Only Nemal offers the quality construction RG59/U copper shielding made to mil spec JAN C-17 12-gauge conductors tinned copper drain wires and a true direct burial polyethylene jacket

HARDLINE

Two styles, two sizes for all installation needs

- **Aluminum Outer Conductor with Polyethylene Jacket**
  - 1/2 inch loss 48 dB/100 ft. @ 30 MHz; 3.68 dB/100 ft. @ 1000 MHz .... $1.25/ft.
  - 7/8 inch loss 28 dB/100 ft. @ 30 MHz; 2.54 dB/100 ft. @ 1000 MHz .... $3.25/ft.
- **Corrugated Copper Outer Conductor with Polyethylene Jacket**
  - 1/2 inch loss 38 dB/100 ft. @ 30 MHz; (FLC12-50J) 2.78 dB/100 ft. @ 1000 MHz .... $1.59/ft.
  - 7/8 inch loss 13 dB/100 ft. @ 30 MHz; (FLC12-78J) 1.3 dB/100 ft. @ 1000 MHz .... $3.92/ft.

COMPARE RG 213 1.25 dB/100 @ 30 MHz; 8.5 dB/100 @ 1000 MHz !

HARDLINE CONNECTORS

1/2 inch aluminum UHF M/F $19.00 Type N M/F $22.00
7/8 inch aluminum UHF M/F $49.00 Type N M/F $49.00
1/2 inch copper UHF M/F $22.00 Type N M/F $22.00
7/8 inch copper UHF M/F $49.00 Type N M/F $49.00

shipping
Cable — $6.00 per 100 ft.
Connectors — $3.00 per order.
Orders under $20 add $2 additional plus shipping.
Charge card — orders over $30 only.
COD add $2.00. Florida Residents add 5%.

COAXIAL CABLE SALE
POLYETHYLENE DIELECTRIC

RG-8/U 96% shield Mil Spec .... ($29.00/100) or 31¢/ft.
RG11U 96% shield 75 ohm mil spec .... 25¢/ft.
RG-55B/U double shield (RG-58 size) 50 ohm .... 45¢/ft.
RG58U mil spec 96% shield .... ($10.00/100) or 11¢/ft.
RG62A/U 96% shield mil spec 93 ohm .... 12¢/ft.
RG174/U min. 50 Ω mil spec .... 10¢/ft.
RG213 noncontaminating 96% shield mil spec .... 36¢/ft.
RG214/U double silver shield 50 ohm .... $1.65/ft.
RG214/U tinned copper .... 65¢/ft.
RG217/U double shield 50Ω 5/8" OD .... 85¢/ft.

LOW LOSS FOAM DIELECTRIC

RG-8X (Mini 8) 95% shield .... ($15.00/100) or 17¢/ft.
RG8U 80% shield .... ($19.00/100) or 22¢/ft.
RG-8/U 97% shield 11 gu. (eq. Belden 8214) .... 31¢/ft.
RG58U 80% shield .... 07¢/ft.
RG58U 95% shield .... 10¢/ft.
RG59/U 100% foil shield TV type .... 10¢/ft.
RG59/U 70% copper shield .... 09¢/ft.
HEAVY DUTY ROTOR CABLE 2-16 ga 6-20 ga .... 36¢/ft.
Rotor cable 2-18 ga 6-22 ga Poly burial Jkt. .... 19¢/ft.
Complete line of multiconductor cables available

CONNECTORS MADE IN USA

Amphenol PL-259 .... 89¢
PL-259 and/or SO-239 .... 65¢ ea. or 10/$5.99
Double Male Connector $1.79
PL-258 Double Female Connector .... 98¢
PL-259 Silver-Teflon Kings .... $1.59 ea.
Reducer UG-175 or 176 .... 22¢ or 10/$2.00
UG-255 (PL-259 to BNC) $2.95
Elbow (M359) UHF Elbow $1.79
F59A (TV type) .... 24¢ or 10/$2.00
UG 21 D/U Type N Male for RG8, Amphenol $3.00
UG-88C/U BNC Male for RG-58, Amphenol $1.25
UG 273 BNC-PL259 Amphenol $3.00
3/16 inch Mike Plug for Collins etc. (cutoff) $1.25

shipping
Cable — $3.00 per 100 ft.
Connectors — add 10%, $3.00 minimum.
Orders under $20 add $2 additional plus shipping.
Charge card — orders over $30 only.
COD add $2.00. Florida Residents add 5%.

FACTORY AUTHORIZED DISTRIBUTOR
AMPHENOL, CABLEWAVE, COLUMBIA, KINGS
BLONDER-TONGUE, TYTON, B&K

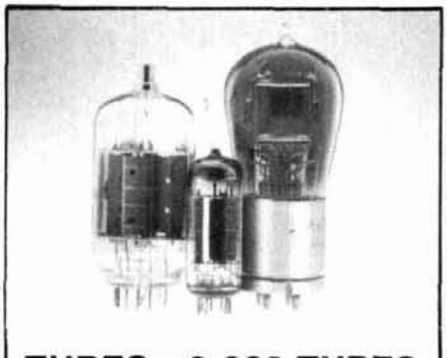
- COAXIAL CABLE
- *MULTICONDUCTOR CABLE*
- CONNECTORS-ADAPTERS
- HARDLINE
- CABLE TIES
- SMATV PRODUCTS
- *COAX-SEAL*
- COMPUTER CABLE
- CRIMP TOOLS
- FIELD STRENGTH METER

VISA MasterCard

12240 N.E. 14th Ave.
No. Miami, FL 33161
Telephone: (305) 893-3924

IN STOCK
— OVER 500 ITEMS —
COMPLETE LINES

✓ 129



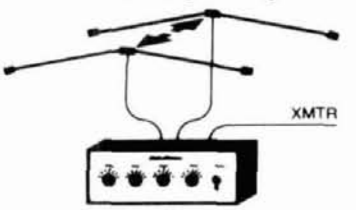
TUBES—2,000 TYPES
DISCOUNT PRICES!

New 20-pg. wholesale catalog for the radio collector/hobbyist. Antique, hard-to-find and modern tubes. *Also transformers, capacitors* and parts for tube equipment, and books, etc.

Antique Electronic Supply
688-F W. First Street
Tempe, AZ. 85281
602/894-9503

✓ 176

40m Phased Array —the Easy Way!



OPTI•PHASOR™ by BaileyTech

- Change direction instantly
- High F/B, adjustable phasing
- Low SWR over entire 40m band
- Just 2 dipoles gives 4 db gain

$119.95 Also available with matched dipoles and feed lines

Check, MO, VISA, M/C
Call or Write for Complete Catalog.
TET Antennas, Larsen, Hy-Gain, Alpha Delta, etc.

SULTRONICS
1587 U.S. 68 N Xenia, OH 45385
(513) 376-2700

✓ 111

AUTHORIZED KENWOOD I-COM RADIO DEALER

H.L. HEASTER, INC.
KENWOOD
ICOM
203 Buckhannon Pike, Clarksburg, W.Va.

✓ 151

H. L. HEASTER, INC., 203 Buckhannon Pike, Clarksburg, W. Va. 26301 Clarksburg Phone (304) 624-5485 or W. Va. Toll-Free 1-800-352-3177

HAROLD HEASTER, KA8OHX, 91 Ridgefield Place, Ormond Beach, Fl. 32074 Florida Phone (904) 673-4066

NEW NATION-WIDE TOLL-FREE TELEPHONE 1-800-84-RADIO
1-800-84-72346

Call us for a quotation, WE WILL SAVE YOU MONEY!

GUS BROWNING, W4BPD's
DX'ERS MAGAZINE

For over 17 years, Gus's DX'ERS MAGAZINE has brought thousands of DX'ERS worldwide, timely, pertinent information on when and where to find those elusive DX stations.

Gus's personable, chatty writing style and his years of DX operating experience makes the DX'ERS MAGAZINE a unique publication. One year $14.00 USA, Canada & Mexico.

Gus also prints high quality QSLs and other related items.
✓ 156 **Write today for a free sample of his QSLs and DX'ERS MAGAZINE.**

Gus Browning, W4BPD • PO Drawer 405 • Cordova, SC 29039

NEW products

MFJ-815 cross-needle SWR/wattmeter

MFJ's new cross-needle SWR/wattmeter, the MFJ-815, enables hams to read SWR, forward, and reflected power at a single glance. No SWR setting is needed at any range.

The average forward and reflected power can be read in three ranges: 20/200/2000 watts forward and 5/50/500 watts reflected. SWR can be read from 1:1 to 5:1 on a two-color scale. This unit works from 1.8 to 30 MHz, and accuracy

is ± 10 percent full scale. The MFJ-815 also features easy push-button range selectors.

The MFJ-815 sells for a retail price of $59.95 each, and can be found at many of the MFJ dealerships nationwide. All MFJ products are backed by a one-year unconditional warranty and an additional 30-day guarantee covering products purchased directly from the company.

For further information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

Circle #302 on Reader Service Card.

questions about satellite TV? free booklet has the answers

Seventy-eight of the most frequently asked questions about satellite TV are answered in a new 16-page, 6 by 9-inch booklet available free from Luxor.

Arranged in an easy-to-follow question & answer format, *Everything You Need To Know About Home Satellite TV* is divided into seven sections: "Getting Started," "The Channels," "The 'Birds,'" "Satellite TV Programming," "The Dish," "Satellite TV Receivers," and "Tuning In." Diagrams such as shown in **fig. 1** illustrate the basic operation of a home satellite TV system, the location of the Clarke satellite belt, and a typical satellite "footprint."

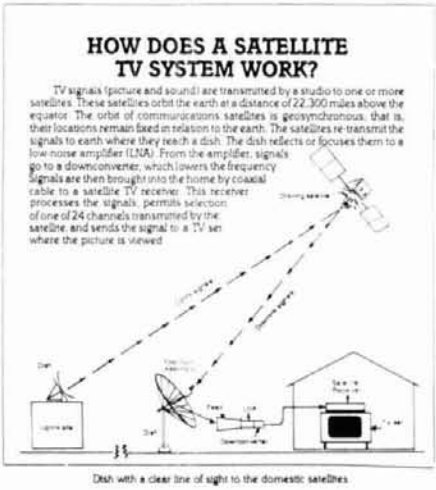


fig. 1. Luxor's free 16-page booklet answers commonly-asked questions about home satellite TV, using text and illustrations such as this.

Free copies are available from Luxor North America Corporation, 600 108th Avenue N.E., Bellevue, Washington 98004.

Circle #304 on Reader Service Card.

tough tool kits

A selection of best-selling field engineer's tool kits from Jensen Tools, Inc. is now available in rugged military style cases. Designed to endure rough handling and harsh industrial or military environments, these cases are molded of high-density polyethylene and are 20 to 25 per cent thicker than conventional cases, and can withstand temperature extremes ranging from -200 F to +185 F.

Unique features include a permanent olive drab (FFD-STD-595) finish; heavy-duty tongue and groove aluminum valance with gasket to seal out dirt and moisture; combination lock and padlock loops for added security; spring-loaded handles, low profile, quarter-turn latches; and molded-in stacking lugs to provide strength and secure stacking during storage.

These cases are offered with the Jensen JTK-17, JTK-87 or JTK-99 tool and pallet selections, or they can be bought separately without tools.

For more information or a free catalog, contact Jensen Tools Inc., 7815 South 46th Street, Phoenix, Arizona 85044.

Circle #305 on Reader Service Card.

High Performance vhf/uhf preamps

Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	<1.1	15	0	DGFET	$29.95
P50VD	50-54	<1.3	15	0	DGFET	$29.95
P50VDG	50-54	<0.5	24	+12	GaAsFET	$79.95
P144VD	144-148	<1.5	15	0	DGFET	$29.95
P144VDA	144-148	<1.0	15	0	DGFET	$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	$79.95
P220VD	220-225	<1.8	15	0	DGFET	$29.95
P220VDA	220-225	<1.2	15	0	DGFET	$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	$79.95
P432VD	420-450	<1.8	15	−20	Bipolar	$32.95
P432VDA	420-450	<1.1	17	−20	Bipolar	$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	$79.95
Inline (rf switched)						
SP28VD	28-30	<1.2	15	0	DGFET	$59.95
SP50VD	50-54	<1.4	15	0	DGFET	$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	$109.95
SP144VD	144-148	<1.6	15	0	DGFET	$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	$109.95
SP220VD	220-225	<1.9	15	0	DGFET	$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
SP432VD	420-450	<1.9	15	−20	Bipolar	$62.95
SP432VDA	420-450	<1.2	17	−20	Bipolar	$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

Every preamplifier is precision aligned on ARR's Hewlett Packard HP8970A/HP346A state-of-the-art noise figure meter. RX only preamplifiers are for receive applications only. Inline preamplifiers are rf switched (for use with transceivers) and handle 25 watts transmitter power. Mount inline preamplifiers between transceiver and power amplifier for high power applications. Other amateur, commercial and special preamplifiers available in the 1-1000 MHz range. Please include $2 shipping in U.S. and Canada. Connecticut residents add 7-½% sales tax. C.O.D. orders add $2. Air mail to foreign countries add 10%. Order your ARR Rx only or Inline preamplifier today and start hearing like never before!

Advanced Receiver Research

Box 1242 • Burlington, CT 06013 • 203 582-9409

MasterCard VISA

187

ENGINEERING PROGRAMS FOR THE IBM-PC

RF-CAD ELECTRONICS DESIGN PROGRAM Version 3.51

by Joe Reisert, W1JR and Gary Field, WA1GRC
For IBM PC and compatable computers

This software package has been written by electronic engineers and contains nearly 40 tested and proven programs that will help the Radio Amateur or engineer design many common types of radio circuitry. Emphasis has been placed upon ease of use. Wherever possible, menus of choices with examples are displayed. Should the user be computer literate, the programs are not copy protected so they can be modified to meet your specific requirements. (full documentation is also provided.) Programs include: Filters, LC, active- LP,HP,BP; Inductor design, torroid, solenoid, straight wire; Matching networks; Crystal oscillators; Microstrip; Transmission lines; Antennas, Yagi-Uda, helix, dish, horn, element scaling; Pi and T attenuators. Also included: Radio Path calculations; FM modulation analysis, Miscellaneous conversions; Geostationary satellite pointing; Moon tracking aids; Receiver noise figure calculations and Spurious receiver response prediction. Requires IBM-PC with at least one floppy drive and 128k of RAM. ©1985

RF-CAD **$39.95**

Please enclose $3.50 to cover shipping, handling

VISA MasterCard

ham radio magazine BOOKSTORE GREENVILLE, NH 03048

STATION MANAGER/ADVANCED

A General Purpose Logging Program

Designed for the IBM® PC,® XT,® enhanced PC jr.® Menu driven; prompts for easy use; full color displays; multiple logs (each up to 1,000 entries with user editing), several reporting methods including one by partial callsign.

$59.00 includes: 90 pg. User's Guide & Diskette (source code included)
$20.00 — User's Guide only (may be applied to full purchase price)
Ohio residents include sales tax

WATCH FOR STATION MANAGER/CodeTutor To be released soon 127

OMEGA CONCEPTS

Professional software for the Radio Amateur™

P.O. Box 615
Troy, OH 45373

T.L. Jones (KB80A)
Author

IBM is a registered trademark of International Business Machine Corp.

DRAKE R-4/T-4X OWNERS AVOID OBSOLESCENCE

PLUG-IN SOLID STATE TUBES!
Get state-of-the-art performance.
Most types available

INSTALL KITS TO UPGRADE PERFORMANCE!

- BASIC Improvement
- Audio Bandpass Filter
- Audio IC Amplifier

TUBES $23 PPD **KITS $25 PPD**

OVERSEAS AIR $7

SARTORI ASSOCIATES, W5DA
BOX 832085
RICHARDSON, TX 75083
214-494-3093 116

"HAM HOTLINE"
THE PROVEN MONEYMAKER

The **"Ham Hotline"** is a complete mailing list of novice amateur radio operators and current hams who have renewed, upgraded or modified their FCC licenses. These ham enthusiasts have proven to be excellent prospects for radio equipment, accessories and publications.

The Hotline is **UPDATED EVERY TWO WEEKS** with an average of 8,000 names and addresses each month. And, because we know the Hotline is the most up-to-date amateur radio listing available, we'll guarantee 98% deliverability.

Target your sales efforts to your most likely buyers. Call DCC Data Service today and begin your subscription to the **"Ham Hotline"** . . . the proven moneymaker. 159

DCC Data Service
1990 M Street, N.W. Suite 610
Washington, D.C. 20036

Toll-free 1-800-431-2577

In DC & AK 202-452-1419

NEW products

CW manual

This manual (with tape) from Gordon West is a complete guide to assist you in passing the 5, 13, and 20 WPM code exams. This is not a Morse Code training or speed building kit, but rather a program of successfully applied exercises to help you understand and deal with problem areas.

How to Read What You Writ! addresses many topics including why students do not pass the code exams; how to avoid the common errors; setting goals in code practice; reading the material and finding answers once you've copied the code; dealing with code opposites and letters and numbers that are easily confused; word and sentence techniques; overcoming plateaus, and what to do when test day finally arrives.

How To Read What You Writ! is available directly from Loraine McCarthy, Code Programs Manager, Gordon West's Radio School, 315½ Ruby, Balboa Island, California 92662. The price is $14.95. All orders are shipped by first class mail the same day. (Add $2.00 postage and handling.)

Circle #301 on Reader Service Card.

Heathkit catalog

Several new products are featured in Heath's new catalog. Included are four new Amateur Radio products: an antenna noise bridge for pinpointing the cause of mismatches in antenna systems; a VLF Converter for receiving the 10 to 500 kHz band between 3.5 MHz and 4.0 MHz on a receiver; an active SWL Antenna for receiving signals between 30 kHz and 30 MHz; and a new touchtone decoder for eliminating extraneous monitor racket.

Six new test instruments have also been added: a new radiation monitor, the RM-4, is a handheld device for measuring radiation in the alpha, beta, gamma, and X-ray spectrums. The new PMK-130 RS-232 hand-held Breakout Box, designed for troubleshooting computer interface problems, allows access to all 25 communication lines. The Heath Digital LC Bridge, model IT-2240 Dual Trace Oscilloscope provides a wide DC to 25 MHz bandwidth.

More than 400 products are available. For a free copy contact Heath Company, Dept. 150-597, St. Joseph, MI. (In Canada, contact Heath Company, 1020 Islington Avenue, Dept. 3100, Toronto, Ontario, M8Z3.

Circle #303 on Reader Service Card.

flea market

RATES Noncommercial ads 10¢ per word; commercial ads 60¢ per word **both payable in advance**. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

SCHEMATIC: Radio receivers 1920's/60's. Send brand name, model No., SASE Scaramella. PO Box 1, Woonsocket, RI 02895-0001.

TEMPO S5T mint, with case, ducks, 5/8 gain antenna, charger, S30 amplifier, all manuals. $225 or best offer. Dennis, KA1BYQ, (203) 243-9458 or 528-9756.

THE GOOD SAM HAMS invite RV operators to check in the Good Sam Ham net 14.240 Sundays 1900Z also 3.880 Tuesdays at 2359Z. Net control N5BDN, Clarksville, IN

OLD RADIO transcription discs wanted. Any size, speed. W7FIZ, Box 724 HR, Redmond, WA 98073-0724.

RTTY-EXCLUSIVELY for the Amateur Teleprinter. One year $10.00. Beginners RTTY Handbook $8.00. PO Box RY, Cardiff, CA 92007.

IBM-PC RTTY/CW. CompRtty II is the complete RTTY/CW program for the IBM-PC and compatibles. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in editor! 10,000 character transmit/receive buffers. Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Now with WRU (simple mailbox). Ideal for MARS and traffic handling. Requires 128k PC, XT, AT, PCjr, PC-DOS, serial port, RS-232C TU $65. Send call letters (including MARS) with order. Mention Ham Radio Magazine and take $10 off. David A. Rice, KC2HO, 7373 Jessica Drive, North Syracuse, NY 13212.

UHF PARTS. We stock GaAs Fets, Trimmers, and many of those impossible to find parts for the UHF builder. For example: MGF 1202 at $10.00, Finger Stock at $7.50 per 16" strip. SASE brings list, Microwave Components, 11216 Cape Cod, Taylor, MI 48180.

IMRA, International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 2-3 PM Eastern. Eight hundred Amateurs in 40 countries. Brother Frey, 1 Pryer Manor Road, Larchmont, New York 10538.

Foreign Subscription Agents for Ham Radio Magazine

Ham Radio Austria
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio Belgium
Stereohouse
Brusselsesteenweg 416
B-9218 Gent
Belgium

Ham Radio Holland
Postbus 413
NL-7800 Ar Emmen
Holland

Ham Radio Europe
Box 2084
S-194 02 Upplands Vasby
Sweden

Ham Radio France
SM Electronic
20 bis, Ave des Clarions
F-89000 Auxerre
France

Ham Radio Germany
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Canada
Send orders to
Ham Radio Magazine
Greenville, NH 03048 USA
Prices in Canadian funds
1 yr $29.95, 2 yrs $53.30
3 yrs $75.40

Ham Radio Italy
Via Maniago 15
I-20134 Milano
Italy

Ham Radio Switzerland
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio England
c/o R.S.G.B.
Alma House
Cranborne Road
Potters Bar
Herts EN6 3JW
England

RUBBER STAMPS: 3 lines $4.50 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. Daily Electronics, PO Box 5029, Compton, CA 90224. (213) 774-1255.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. Hein Specialties, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

RESISTORS any value quantity, 1/4 watt @ $.01, 1/2 watt @ $.015 ($1.00 minimum). Quantity discounts, 1,000 + . Send wattage(s), value(s), quantity(s), and remittance to T.O.R.C.C.C. Electronics, box 47148, Chicago, Illinois 60647. (312) 342-9171.

ELECTRON TUBES Radio & TV types 75% off list price huge inventory! Also industrial types. Send for Free Catalog today or call Toll Free (800) 221-5802. Box HC Transleteronics, Inc, 1365 39th Street, Brooklyn, NY 11218

NEW PACKET RADIO PROGRAM for IBM PC's. A telecom program for interfacing your PC with your packet controller. Special functions for GLB's. 5 page scrolling screen with cursor control. Two types Binary File Transfers. 300-9600 bps. Keyboard Macros. 50 page manual. Split screens. Windows! Much more. NON COPY PROTECTED. $49.95 + $3.00 shipping and handling. Kalt & Associates, Suite#138, 2440 E. Tudor Rd., Anchorage, AK 99507. (907) 248-0133. Write for more info.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

PRINTED CIRCUIT BOARDS and kits for QST articles. Call or write for information. A&A Engineering, 7970 Orchid Drive, Buena Park, CA 90620. (714) 521-4160.

R-390A RECEIVER. .5-30 MHz all modes, 4 mechanical filters, meters sealed (Government removed, operation unaffected): complete/checked $195, complete/repairable $115, spare parts unit (80% complete) $65. CPRC 26 Manpack Radio (described in March 1985 Ham Radio), transceives 46-54 MHz FM, with battery box, antenna, crystal, handset: $22.50 apiece, $42.50/pair. Info SASE. CPRC-26 add $4/unit shipping. R-390A shipping charges collect. Baytronics, Dept. HR, Box 591, Sandusky, OH 44870. (419) 627-0460 evenings.

CIRCUIT BOARDS Guaranteed lowest quotes and Free twelve hour prototypes. Single and double sided boards. Small through large production quantities. Mail specifications. Hobbyists any schematic 6" x 9" maximum, etched on a 3" x 4" board $1.50. (larger boards $2.50). Send remittance and schematic or art work or, print your own circuit boards. Kits of all sizes. Guaranteed lowest prices. Basic kit $2.75. Materials for two 3" x 4" boards (included) or SASE for catalog. T.O.R.C.C.C. Electronics, Box 47148, Chicago, Illinois 60647. (312) 342-9171.

PACKET/ASCII/BAUDOT/CW for IBM-PC. SASE to: Emile Alline, 773 Rosa, Metairie, LA 70005.

PRINTED CIRCUIT BOARDS TORCCC Electronics will print any schematic, 6"x9" maximum, on a circuit board for $1.50 (larger schematics add $1.25 per additional 50 square inches). Send check and schematic to: TORCCC Electronics, 2161 North California, Chicago, Illinois 60647.

WANTED NC400 receiver. Any condition. W2PUA, 112 Tilford Road, Somerdale, NJ 07083. (609) 783-4175.

DRAKE! DRAKE! DRAKE! Complete station with late model TR7A/DR7 transceiver and R7A receiver, speech processor, speaker, power supply, fans, cross-connect cables, manual. Asking $1550. Guaranteed excellent condition or I pay for repair. Gary Jordan, WA6TKT, 1012 Olmo Court, San Jose, CA 95129 (408) 257-2222.

CABLE TV CONVERTERS/DESCRAMBLERS. Guaranteed lowest prices in US. Jerrold, Hamlin, Zenith Many others. Lowest dealer prices! Orders shipped within 24 hours! Complete illustrated catalog, $2.00. Pacific Cable Co., Inc., 7325-1/2 Reseda Blvd,#1009, Reseda, CA 91335. (818) 716-5914.

WANTED: NEED URGENTLY schematic operations manual for Honeywell 6869 VLF Receiver. H. Weber, 2605 W. 82nd Place, Chicago, IL 60652.

CHASSIS and cabinet kits. SASE K3IWK.

IC-25A FOR SALE: $225 or best offer. Good condition, used only as a mobile radio. Call Craig (603) 878-1441, 9-5 EST, M-F only.

DIGITAL AUTOMATIC DISPLAYS. All transceivers. Six 1/2" digits. 5" wide by 1-1/4" by 9" cabinet! Send $1.00 for information. Be specific. Grand Systems, POB 2171, Blaine, Washington 98230.

CB to 10M CONVERSIONS. FM kits, frequency modification hardware, books, plans, high-performance CB accessories. Free catalog. CBCI, Box 31500HR, Phoenix AZ 85046. (602) 996-8700.

CABLE TV CONVERTERS & EQUIPMENT: Plans and parts. Build or buy. FREE information. C & D Electronics, PO Box 1402, Dept. HR, Hope, AR 71801.

RIW-19 432 MHz beams by K3IPW. SASE for information.

HP606B SIGNAL GENERATOR. 50 kHz 65 MHz. Excellent condition, with manual. $290. VE3EAA, Box 2980, Stn. D, Ottawa, Ontario K1P 5W9.

FOR SALE: Bearcat 160, 16 channel, 5 band programmable scanner with memory backup. Needs IC. $109.00. (812) 342-6740.

TEST EQUIPMENT: Lab calibrated signal generators: HP 8640B 500 kHz thru 1024 MHz, AM/FM, with options 002, 003, and 323 portable field carrying case $5,500.00, Marconi, TF 1066B/6, 10 MHz thru 470 MHz AM/FM, $550.00, HP 606A 50 kHz thru 65 MHz $375.00, military TS-510A 10 MHz thru 420 MHz $295.00, military URM 25D, 10 kHz thru 50 MHz $245.00, URM-26B, 4 MHz thru 405 MHz $245.00, HP/Boonton 202H, 54 MHz thru 216 MHz AM/FM $275.00, HP 614A, 900 to 2100 MHz $345.00, HP 608E 10 MHz thru 480 MHz $495.00, HP 628A 15 GHz thru 21 GHz $650.00. Frequency counter HP 5245L with HP 5253B plug-in, range 0-500 MHz $375.00. We accept Visa, M/C, check. Satisfaction guaranteed. Phone Bill Slep, (704) 524-7519. Slep Electronics, Highway 441, Otto, NC 28763.

RESISTORS any value/quantity, 1/4 watt @ $.01, 1/2 watt @ $.015 ($1.00 minimum). Quantity discounts, 1,000 + . Send wattage(s), value(s), quantity(s), and remittance. T.O.R.C.C.C. Electronics, Box 47148, Chicago, Illinois 60647. (312) 342-9171

COLLECTION of 40 Antique Radios and 22 Ham and drum Speakers. Many other items and parts all working. Blair Daley, KA8OOH, Elsie, MI 48831. (517) 862-5228.

COMING EVENTS

Activities — "Places to go . . ."

CALIFORNIA: FCC exams, Novice-Extra. Sunnyvale VEC ARC (408) 255-9000 24 hour. 73, Gordon, W6NLG, VEC

PENNSYLVANIA: The Mercer County Amateur Radio Club invites Amateurs to socialize and exchange views at its "How To" seminar, March 22, 9 AM to 4:30 PM, Hermitage Middle School opposite Shenango Valley Mall, Rt. 18, Hermitage. License exams, Novice through Extra, will be given. Examinees and those under 18 years admitted free. For others admission is $2.00. Call in on 147.75/.15. For details SASE to MCARC, Box 996, Sharon, PA 16146.

MASSACHUSETTS: The Mt. Tom Amateur Repeater Association is having its annual Flea Market, March 2, Knights of Columbus Elder Council 69 on Granby Road, Chicopee. Doors open 8 AM to 3 PM. Food available. Reserved tables $7.00. At the door $8.00. Entrance fee $1.00. Ladies and children under 12 free. For reservations: MTARA, PO Box 3494, Springfield, MA 01101.

MINNESOTA: The Robbinsdale Amateur Radio Club's 5th annual Midwinter Madness Hobby Electronics Show. February 22, Totino-Grace High School, 1350 Gardena Avenue NE, Fridley, MN (suburb of Minneapolis). Admission $3.00 advance; $4.00 at the door.8' flea market tables $8.00. 1/2 tables $4.00. Dealers, flea market, computers, satellite TV, packet radio. Talk in on 147.60/.00 K0LTC repeater and 146.52 simplex.To register send SASE with fees to Robbinsdale ARC, PO Box 22613, Robbinsdale, MN 55422 or call Bob (612) 533-7354. FCC exam registration send completed Form 610, potocopies of current license and code credit plus $4.00 payable to ARRL/VEC to: Neil McMillin, 11132-97th Place, Maple Grove, MN 55369 by January 22, 1986. Limited walk-ins.

KENTUCKY: Annual Glasgow Swapfest, Saturday, February 22, 8 AM tilGlasgow Flea Market Building, 2 miles south of Glasgow off Highway 31E. Free parking. Free coffee and a friendly gathering of hams. Admission $2. No extra charge for exhibitors. One free table per exhibitor. Extra tables $3.00 each. Talk in on 146.34/94. For information: N4HCO, Rt 4, Box 354, Glasgow, KY 42141.

MASSACHUSETTS: The Norwood ARC will hold its annual Flea Market, Saturday, February 22, Norwood Junior High School South, Washington Street. Dealer tables $10.00. Setup 8 AM. General admission $2.00. Open 9 AM. Plenty of free parking and facilities for the handicapped. For information or table reservations: Stan Cottrell, WA1NCV (617) 762-5184. Talk in on 146.520 and 146.895.

ILLINOIS: The Sterling-Rock Falls Amateur Radio Society's 26th annual Hamfest, March 9, Sterling High School Fieldhouse, 1608 Fourth Avenue, Sterling. Distributors, dealers, large flea market and demonstration of Packet Radio. Free parking and space for self contained RV's. Doors open 7:30 AM. Tickets $3.00 advance; $4.00 at the door. Commercial tables $5.00. Others $3.00. For tickets, tables or information: Sue Peters, KA0GMR., PO Box 521, Sterling, IL 61081. (815) 625-9262. Talk in W9MEP 146.25/85.

MASSACHUSETTS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday, February 19, 1986, 7 PM, MIT Room 1-134, 77 Mass Ave, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann (617) 253-5820/646-1641 or Craige Rodgers at 225-6616. Exam fee $4.00 Bring copy of current license, 2 forms of picture ;ID and completed form 610 (available from FCC in Boston, 223-6609.

VIRGINIA: The Vienna Wireless Society will hold its 13th annual Winterfest, February 23, 8 AM, Vienna Community Center, 120 Cherry St., Vienna. Exhibits and demonstrations of new and used Amateur Radio equipment. Tailgating in the "Frostbite" parking lot. Refreshments available. For information: John Arnold, N4IXD, Chairman, 255-2076.

Operating Events — "Things to do . . ."

North Carolina QSO Party sponsored by the Alamance ARC, K4EG, 1400Z February 1 to 0500Z February 2. CW and phone. Work stations once per band/mode. Mobiles as they change county. Exchange RS(T) and ARRL section. Mail logs by 3/1/86 to North Carolina QSO Party, c/o K4EG, PO Box 3064, Burlington, NC 27215.

HAM MART

Ham Radio's guide to help you find your loca

California

C & A ROBERTS, INC.
18511 HAWTHORN BLVD.
TORRANCE, CA 90504
213-370-7451
24 Hour: 800-421-2258
Not The Biggest, But The Best — Since 1962.

FONTANA ELECTRONICS
8628 SIERRA AVENUE
FONTANA, CA 92335
714-822-7710
714-822-7725
The Largest Electronics Dealer in San Bernardino County.

JUN'S ELECTRONICS
3919 SEPULVEDA BLVD.
CULVER CITY, CA 90230
213-390-8003
800-882-1343 Trades
Habla Espanol

Colorado

COLORADO COMM CENTER
4262 LOWELL BLVD.
DENVER, CO 80211
(303) 433-3355
(800) 227-7373
Stocking all major lines
Kenwood,Yaesu, Encomm

Connecticut

HATRY ELECTRONICS
500 LEDYARD ST. (SOUTH)
HARTFORD, CT 06114
203-527-1881
Call today. Friendly one-stop shopping at prices you can afford.

Delaware

AMATEUR & ADVANCED COMMUNICATIONS
3208 CONCORD PIKE
WILMINGTON, DE 19803
(302) 478-2757
Delaware's Friendliest Ham Store.

DELAWARE AMATEUR SUPPLY
71 MEADOW ROAD
NEW CASTLE, DE 19720
302-328-7728
800-441-7008
Icom, Ten-Tec, Microlog, Yaesu, Kenwood, Santec, KDK, and more.
One mile off I-95, no sales tax.

Florida

AMATEUR ELECTRONIC SUPPLY
1898 DREW STREET
CLEARWATER, FL 33575
813-461-4267
Clearwater Branch
West Coast's only full service Amateur Radio Store.
Hours M-F 9-5:30, Sat. 9-3

AMATEUR ELECTRONIC SUPPLY
621 COMMONWEALTH AVE.
ORLAND, FL 32803
305-894-3238
Fla. Wats: 1 (800) 432-9424
Outside Fla: 1 (800) 327-1917
Hours M-F 9-5:30, Sat. 9-3

Georgia

DOC'S COMMUNICATIONS
702 CHICKAMAUGA AVENUE
ROSSVILLE, GA 30741
(404) 866-2302
ICOM, Yaesu, Kenwood, KDK, Bird...
9AM-5:30PM
We service what we sell.

Hawaii

HONOLULU ELECTRONICS
819 KEEAUMOKU STREET
HONOLULU, HI 96814
(808) 949-5564
Serving Hawaii & Pacific area for 53 years.

Illinois

ERICKSON COMMUNICATIONS, INC.
5456 N. MILWAUKEE AVE.
CHICAGO, IL 60630
312-631-5181
Hours: 9:30-5:30 Mon, Tu, Wed & Fri; 9:30-8:00 Thurs; 9:00-3:00 Sat.

Indiana

THE HAM STATION
220 N. FULTON AVE.
EVANSVILLE, IN 47710
812-422-0231
Discount prices on Ten-Tec, Cubic, Hy-Gain, MFJ, Azden, Kantronics, Santec and others.

Massachusetts

James Millen Components by
ANTENNAS ETC.
16 HANSOM ROAD
ANDOVER, MA 01810
617-475-7831
Bezels, binding posts, capacitors, condensers, chokes, coils, ceramics, H.V. connectors, plate caps, hardware knobs, dials, scopes and grid dippers. Inquire SASE or visit.

TEL-COM, INC.
675 GREAT ROAD, RTE. 119
LITTLETON, MA 01460
617-486-3400
617-486-3040
The Ham Store of New England You Can Rely On.

Michigan

ENCON PHOTOVOLTAICS
Complete Photovoltaic Systems
27600 Schoolcraft Rd.
Livonia, Michigan 48150
313-523-1850
Amateur Radio, Repeaters, Satellite, Computer applications.
Call Paul WD8AHO

Minnesota

TNT RADIO SALES
4124 WEST BROADWAY
ROBBINSDALE, MN 55422 (MPLS/ST. PAUL)
TOLL FREE: (800) 328-0250
In Minn: (612) 535-5050
M-F 9 AM-6 PM
Sat 9 AM-5 PM
Ameritron, Bencher, Butternut, Icom, Kenwood

Missouri

MISSOURI RADIO CENTER
102 NW BUSINESS PARK LANE
KANSAS CITY, MO 64150
(800) 821-7323
Missouri: (816) 741-8118
ICOM, Kenwood, Yaesu
Same day service, low prices.

Nevada

AMATEUR ELECTRONIC SUPPLY
1072 N. RANCHO DRIVE
LAS VEGAS, NV 89106
702-647-3114
Dale Porray "Squeak," AD7K
Outside Nev: 1 (800) 634-6227
Hours M-F 9-5:30, Sat. 9-3

New Jersey

KJI ELECTRONICS
66 SKYTOP ROAD
CEDAR GROVE, NJ 07009
(301) 239-4389
Gene K2KJI
Maryann K2RVH
Distributor of: KLM, Mirage, ICOM, Larsen, Lunar, Astron. Wholesale - retail.

Dealers: YOU SHOULD BE HERE TOO! Contact Ham Radio now for complete details.

New York

BARRY ELECTRONICS
512 BROADWAY
NEW YORK, NY 10012
212-925-7000
New York City's Largest Full Service Ham and Commercial Radio Store.

VHF COMMUNICATIONS
915 NORTH MAIN STREET
JAMESTOWN, NY 14701
716-664-6345
Call after 7 PM and save! Supplying all of your Amateur needs. Featuring ICOM "The World System." Western New York's finest Amateur dealer.

North Carolina

F & M ELECTRONICS
3520 Rockingham Road
Greensboro, NC 27407
1-919-299-3437
9AM to 7PM Closed Monday
ICOM our specialty — Sales & Service

Ohio

AMATEUR ELECTRONIC SUPPLY
28940 EUCLID AVE.
WICKLIFFE, OH 44092 (Cleveland Area)
216-585-7388
Ohio Wats: 1 (800) 362-0290
Outside Ohio: 1 (800) 321-3594
Hours M-F 9-5:30, Sat. 9-3

DEBCO ELECTRONICS, INC.
3931 EDWARDS RD.
CINCINNATI, OHIO 45209
(513) 531-4499
Mon-Sat 10AM-9PM
Sun 12-6PM
We buy and sell all types of electronic parts.

UNIVERSAL AMATEUR RADIO, INC.
1280 AIDA DRIVE
REYNOLDSBURG (COLUMBUS), OH 43068
614-866-4267
Featuring Kenwood, Yaesu, Icom, and other fine gear. Factory authorized sales and service. Shortwave specialists. Near I-270 and airport.

Pennsylvania

HAMTRONICS, DIV. OF TREVOSE ELECTRONICS
4033 BROWNSVILLE ROAD
TREVOSE, PA 19047
215-357-1400
Same Location for over 30 Years.

LaRUE ELECTRONICS
1112 GRANDVIEW STREET
SCRANTON, PENNSYLVANIA 18509
717-343-2124
ICOM, Bird, Cushcraft, Beckman, Larsen, Amphenol, Astron, Belden, Antenna Specialists, W2AU/W2VS, Tokyo Hy-Power Labs, WELZ, Daiwa, Sony, Saxton, Vibroplex, Weller.

THE VHF SHOP
16 S. MOUNTAIN BLVD., RTE. 309
MOUNTAINTOP, PA 18707
717-474-9399
Lunar, Microwave Modules, ARCOS, Astron, KLM, Tama, Tonna-F9FT, UHF Units/Parabolic, Santec, Tokyo Hy-Power, Dentron, Mirage, Amphenol, Belden

Texas

MADISON ELECTRONICS SUPPLY
3621 FANNIN
HOUSTON, TX 77004
713-520-7300
Christmas?? Now??

Wisconsin

AMATEUR ELECTRONIC SUPPLY
4828 W. FOND DU LAC AVE.
MILWAUKEE, WI 53216
414-442-4200
Wisc. Wats: 1 (800) 242-5195
Outside Wisc: 1 (800) 558-0411
M-F 9-5:30 Sat 9-3

✓ 190

More Details? CHECK—OFF Page 110

THE GUERRI REPORT by Ernie Guerri, W6MGI

millimeter waves

Part I: the move to higher frequencies

For most Amateurs, the notion of moving to higher frequency bands means operating at or above 144 MHz. A few brave pioneers work in the microwave region — and have precious few contacts to show for it. We could be tempted to forget that for more than 40 years, there has been an avalanche of effort devoted to the development of microwave hardware and systems.

For the purposes of this discussion, "microwaves" will mean the region above 2 GHz — that is, up to about 30 GHz. This is the domain where lumped circuits fail to have physical implementation and where waveguide replaces coax in many low-loss or high-power applications. While military uses were the principal motivator for early work, commercial applications are now the driving force in the region from 2 to 18 GHz.

Band crowding is already a major issue in the microwave region. By the mid-1960s, the military had found use for nearly everything up to about 20 GHz. Then came the demands for commercial satellite uses, followed by the expansion of terrestrial links to take advantage of all the information the satellites were sending. By the early 1980s, interference was an issue in some frequency bands. The result has been a critical examination of the technologies needed to make higher frequencies available for both commercial and military applications.

These higher frequencies are known as *mm waves* — and, for convenience, are generally defined as the wavelengths from 10 mm to 1 mm (30 to 300 GHz). One of the obvious advantages of this new domain is the amount of spectrum space available: 270 GHz.

Among the advantages that mm systems offer are broad bandwidths (good for high speed data links), higher spatial resolution, less interference due to narrow antenna beams, and, at the high end of the range (near 300GHz), a favorable alternative to optical (infra-red) technologies.

Much work has already been done in this region, but the advent of computer modeling techniques is advancing the rate at which progress can be made. A major limitation on the use of mm waves has been the lack of appropriate devices, hardware, and test equipment. Within the past two years, however, there have been significant developments in each of these areas.

The generation and detection of mm waves requires the use of components and techniques that are unfamiliar to most Amateurs. Semiconductor devices are the only sources of RF power at frequencies above 30 GHz. In general, these devices take the form of negative resistance oscillators and depend on the characteristics of special diodes. The more common of these diodes are GUNN diodes, named for the discoverer of transferred electron devices; IMPATTs (*I*mpact *I*onization *A*valanche *T*ransit *T*ime); and TRAPATTs (*T*rapped *P*lasma *A*valanche *T*riggered *T*ransit).

Each of these devices has characteristics that make it best for certain applications. The tradeoffs are between frequency (of operation), power output, and noise. IMPATT dioides have been fabricated that can produce 1 watt at about 70 GHz.

Transistors will soon be available for the mm region. GaAs FETs are already being made as small signal amplifiers above 30 GHz, and it shouldn't be too long before HEMT (*H*igh *E*lectron *M*obility) and MESFET (*M*etal *o*n *O*xide) devices are available to 100 GHz or so. Power transistors for this region are still a few years off — but only a few. Other necessary components are being developed quite aggressively, as is test equipment. Hewlett Packard has just announced its first line of mm wave spectrum/network analyzers. Special materials and design techniques will be needed to take best advantage of the promise held by mm waves. Work is underway in each of these areas, and the results will not be more than four to five years away.

ham radio

Next month: Part II — Where Do We Go From Here?

ADVERTISER'S INDEX AND READER SERVICE NUMBERS

Listed below are the page number and reader service number for each company advertising in this issue. To get more information on their advertised products, use the bind-in card found elsewhere in this issue, select the correct reader service number from either the ad or this listing, check off the numbers, fill in your name and address, affix a postage stamp and return to us. We will promptly forward your request to the advertiser and your requested information should arrive shortly. If the card is missing, send all the pertinent information on a separate sheet of paper to: *ham radio* magazine, Attn: Reader Service, Greenville, NH 03048.

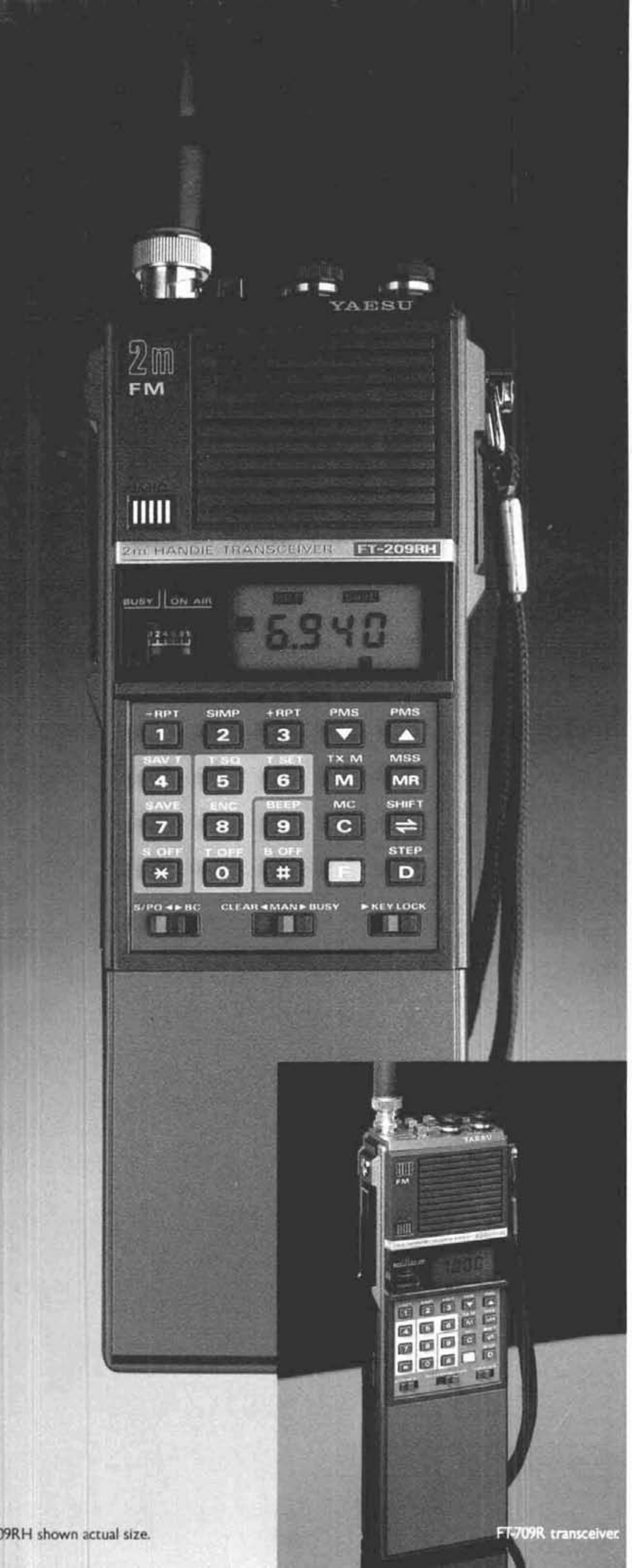
READER SERVICE #		PAGE #
188	Advanced Computer Controls, Inc.	13
187	Advanced Receiver Research	100
183	AEA	1
184	AEA	83
185	AEA	110
186	AEA	97
182	All Electronics Corp.	50
181	Alpha Delta Communications	75
*	Amateur Electronic Supply	82
179	Amateur Wholesale Electronics	23
180	Amateur Wholesale Electronics	81
178	Amentron	63
177	AMSAT	34
176	Antique Electronic Supply	98
175	ARRL	83
*	Barker & Williamson	48
*	Barry Electronics	101
174	Bauman Sales	63
173	Bilal Company	60
172	Buckmaster Publishing	97
*	Butternut Electronics	52
*	Caddell Coil Corp.	52
171	CeCo Communications	62
170	*CMC Communications*	52
169	CMC Communications, Inc.	34
168	Coaxial Dynamics, Inc.	80
167	Colorado Radio	75
166	Communications Concepts, Inc.	38
165	Communications Specialists	16
164	Connect Systems, Inc.	112
163	Crowley Mfg. Co.	108
162	CTM	60
161	Current Development Corp.	102
160	Current Development Corp.	84
*	Dayton Hamvention	111
159	DCC Data Service, Inc.	100
*	Dick Smith Electronics	97
158	Digitrex	80
157	Down East Microwave	75
156	DX'ers Magazine, Gus Browning, W4BPD	98
155	EEB	38
154	EGE	108
*	Engineering Consulting	97
*	Falcon Communications	83
*	Fox Tango Corp.	63
*	Gem Quad	37
152	GLB Electronics	34
151	H.L. Heaster, Inc.	98
150	Hall Electronics	84
149	Ham Radio Outlet	30, 31
*	*Ham Radio's Bookstore*	19, 60, 84, 89, 96, 101, 102, 104
*	The Ham Station	62
*	Hamtronics, NY	67
*	Hamtronics, PA	102
148	Hamtronics, PA	84
190	Harrison Radio	103
147	ICOM America, Inc.	Cover II
145	Jun's Electronics	89
144	Kantronics	37
143	Kendecom/MCS	24
*	Trio Kenwood Communications	2, 5, 7 Cover IV
142	LaCue Communications	83
141	Larsen Electronics	65
140	Lewis Electronics	64
139	LUXOR (North America) Corp.	56, 5
136	*Madison Electronics Supply*	7
137	Madison Electronics Supply	3
138	Madison Electronics Supply	4
135	Meadowlake Corp.	7
146	John J. Meshna Jr., Inc.	7
134	MFJ Enterprises	1
133	Micro Systems Institute	10
132	Microwave Filter, Inc.	4
131	Minds Eye Publications	10
130	Missouri Radio Center	5
129	Nemal Electronics	9
*	*NRI Schools*	2
128	Nuts & Volts	9
127	Omega Concepts	10
*	Orlando Hamcation	9
126	P.C. Electronics	10
125	Pac Comm Packet Radio Systems, Inc.	4
124	Pacific Rim Communications	7
*	Packeterm	4
123	Processor Concepts	10
122	Propagation Publishing	7
107	The PX Shack	3
121	*QSKY Publishing*	8
120	Radio Amateur Callbook	10
119	Radiosporting	10
118	Ramsey Electronics, Inc.	4
117	RF Parts/Westcom Eng.	9
116	Sartori Associates	10
*	Satman, Inc.	10
115	Spec Com	3
114	Spectrum International, Inc.	1
113	Spi Ro Distributing	8
112	STV/OnSat Magazine	10
111	Sultronics	9
189	Tel Com	3
105	TNT Radio Sales, Inc.	11
110	Transverters Unlimited	10
*	University Microfilms Int.	4
104	Vanguard Labs	10
106	The VHF Shop	7
103	W9INN Antennas	9
109	Wacom	4
108	Webster Communications	3
102	Western Electronics	6
101	Yaesu Electronics Corp.	Cover I

PRODUCT REVIEW/NEW PRODUCT

303	Heath Company	10
305	Jensen Tools, Inc.	9
304	LUXOR (North America) Corp.	9
302	MFJ Enterprises	9
301	Radio School	10

*Please contact this advertiser directly. *Limit 15 inquiries per request.*

Please use before March 31, 1986.



9RH shown actual size.

FT-709R transceiver.

High power to get you out. Battery saver to keep you there.

Where other HTs don't make it, Yaesu's 2-meter FT-209RH and 440-MHz FT-709R keep going strong. Here's why:

Our 2-meter model offers you 5 watts output. And our 440-MHz model offers 4½ watts.

Yet there's no excessive battery drain, thanks to a unique user-programmable Power Saver. When activated, it puts the rig "to sleep" while monitoring, and "wakes it up" when the squelch breaks. Thus, you can listen for hours while keeping plenty of power in reserve.

And despite the wealth of advanced features, operation is actually simple and intuitive. That's why our radios are so much easier to "learn" than any other advanced HT.

At the push of a button, you can recall the information you've independently stored in each of the ten memories: receive frequency, standard or non-standard offset, even tone encode/decode.

Monitoring your favorite repeaters or simplex frequencies is just as easy. Just touch a button to scan all memory channels, selected ones, or all frequencies between adjacent memories. And use the priority feature to return automatically to a special frequency.

Bring up controlled-access machines with the optional plug-in subaudible tone encoder/decoder, independently programmed from the keyboard for each channel. Then use the decode function to listen for tone-encoded signals on selected channels—without a lot of chatter.

Finally, both HTs cover 10 MHz, and come complete with a 500-mAh battery, charger and soft case. Options include a VOX headset and hard leather case.

So next time you visit your dealer, pick up Yaesu's 2-meter FT-209RH or 440-MHz FT-709R. Because they not only get you out, they keep you there too.

YAESU

Our 30th Anniversary.

Yaesu Electronics Corporation
6851 Walthall Way, Paramount, CA 90723
(213) 633-4007

Yaesu Cincinnati Service Center
9070 Gold Park Drive, Hamilton, OH 45011
(513) 874-3100

Prices and specifications subject to change without notice.

✓ 101

KENWOOD

...pacesetter in Amateur radio

WAIT 220 MHz Coming soon!

Power-Full...70 Watts!

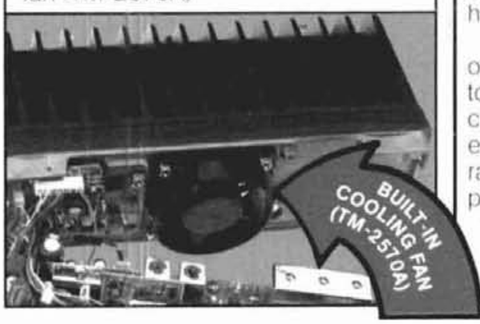
TM-2570A/2550A/2530A

Sophisticated FM transceivers

Kenwood sets the pace again! The all-new "25-Series" brings the industry's *first* compact 70-watt 2-meter FM mobile transceiver. There is even an *auto dialer* which stores 15 telephone numbers! There are three power versions to choose from: The TM-2570A 70-watt model, the TM-2550A for 45-watts, and the 25-watt TM-2530A.

- **First** 70-watt FM mobile (TM-2570A)
- **First** mobile transceiver with telephone number memory and auto-dialer (up to 15 telephone numbers)
- Direct keyboard entry of frequency
- Automatic repeater offset selection according to the ARRL 2-meter band plan —**a Kenwood exclusive!**
- Extended frequency coverage for MARS and CAP (142-149 MHz; 141-151 MHz modifiable)
- 23 channel memory for offset, frequency and sub-tone
- Big multi-color LCD and back-lit controls for excellent visibility
- Front panel programmable 38-tone CTCSS encoder **includes 97.4 Hz** (optional)
- 16-key DTMF pad, with audible monitor
- Center-stop tuning—**another Kenwood exclusive!**
- Frequency lock switch
- **New** 5-way adjustable mounting system
- **Unique** offset microphone connector —relieves stress on microphone cord

Large heatsink with built-in cooling fan (TM-2570A)



- HI/LOW Power switch (adjustable LOW power)
- Compact DIN size

DCL **Introducing... Digital Channel Link**

Compatible with Kenwood's DCS (Digital Code Squelch), the DCL system enables your rig to **automatically** QSY to an open channel. Now you can automatically switch over to a simplex channel after repeater contact! Here's how it works:

The DCL system searches for an open channel, remembers it, returns to the original frequency and transmits control information to another DCL-equipped station that switches **both** radios to the open channel. Microprocessor control assures fast and reliable operation. The whole process happens in an instant!

Actual size front panel

Optional Accessories

- **TU-7** 38-tone CTCSS encoder
- **MU-1** DCL modem unit
- **VS-1** voice synthesizer
- **PG-2K** extra DC cable
- **PG-3A** DC line noise filter
- **MB-10** extra mobile bracket
- **CD-10** call sign display
- **PS-430** DC power supply for TM-2550A/2530A
- **PS-50** DC power supply for TM-2570A
- **MC-60A/MC-80/MC-85** desk mics.
- **MC-48** extra DTMF mic. with UP/DWN switch
- **MC-42S** UP/DWN mic.
- **MC-55** (8-pin) mobile mic. with time-out timer
- **SP-40** compact mobile speaker
- **SP-50** mobile speaker
- **SW-200A/SW-200B** SWR/power meters
- **SW-100A/SW-100B** compact SWR/power meters
- **SWT-1** 2m antenna tuner

Complete service manuals are available for all Trio-Kenwood transceivers and most accessories. Specifications and prices are subject to change without notice or obligation.

KENWOOD

TRIO-KENWOOD COMMUNICATIONS
1111 West Walnut Street
Compton, California 90220